

89

TRANSACTIONS
OF THE
ROYAL SOCIETY OF SOUTH AFRICA

VOLUME X.

1922.

WITH THIRTEEN PLATES, ONE FOLDING MAP,
AND ONE FOLDING TABLE.

CAPE TOWN:
PUBLISHED BY THE SOCIETY.

—
1922.

Q 85
C 23
V. 10

STATE OF
VIRGINIA

Printed in Great Britain by
NEILL & CO., LTD., EDINBURGH.

CONTENTS

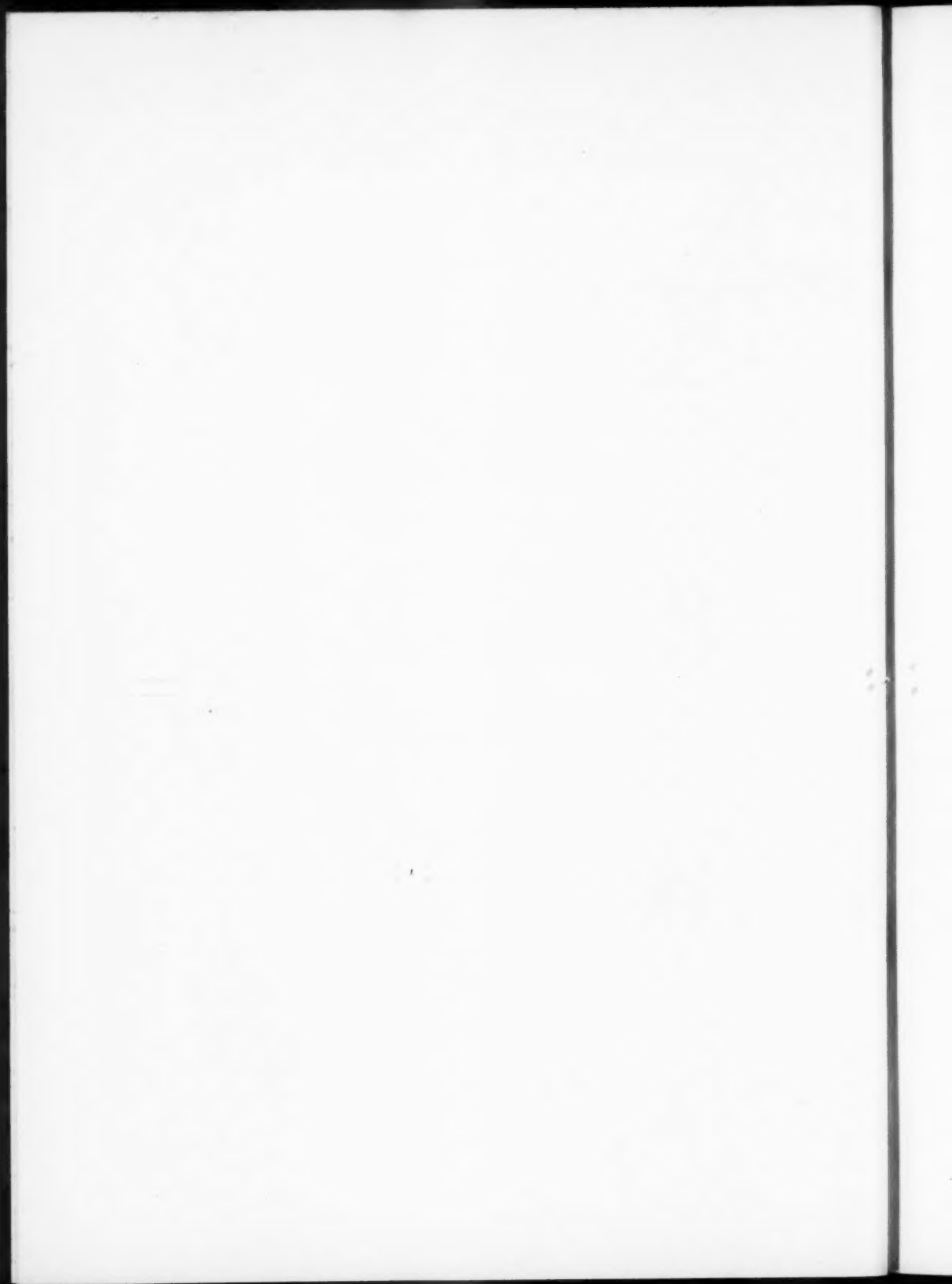
	PAGE
THE ACTION OF <i>Eucomis undulata</i> , AIT.- By J. W. C. GUNN. (With three Text-figs.)	1
THE WATER RELATIONS OF THE PINE (<i>Pinus Pinaster</i>) AND THE SILVER TREE (<i>Leucadendron argenteum</i>). By R. D. AITKEN, M.Sc. (With one Text-fig.)	5
NOTE ON AXISYMMETRIC ORTHOGONANTS. By Sir THOMAS MUIR, LL.D., F.R.S.	21
OBSERVATIONS ON LIVING FISHES BROUGHT BY H.M.S. "CHALLENGER" FROM TROPICAL EAST AFRICA TO CAPE WATERS. By J. D. F. GILCHRIST	23
NOTES ON THE DEVELOPMENT OF THE OVULE, EMBRYO SAC, AND EMBRYO OF <i>Hydnora africana</i> , THUNB. By R. H. DASTUR, B.Sc. Bombay, F.L.S. (With thirteen Text-figs.)	27
(1) THE PERMANGANATE ABSORPTION-SPECTRUM: A CLAIM FOR PRIORITY. (2) A FORMULA FOR CALCULATING THE URANIUM SPECTRUM. By JAMES MOIR	33
COLOUR AND CHEMICAL CONSTITUTION. PART XIII.—THE CALCULATION OF THE COLOUR OF THE MONOCYCLIC DYES. By JAMES MOIR	35
ON <i>Braula Caeca</i> , NITZSCH, A DIPTEROUS PARASITE OF THE HONEY BEE. By S. H. SKAIFE, M.A., M.Sc. (With eleven Text-figs.)	41
NOTE ON A FIRE-FLINT OF STRANDLOOPER ORIGIN. By JOHN HEWITT. (With Plate I)	49
A NOTE ON THE USE OF THE SOUTH AFRICAN CLAWED TOAD IN THE BIOLOGICAL ASSAY OF THE DIGITALIS SERIES. By J. W. C. GUNN	55
SUNSPOTS AND EARTH TEMPERATURES. By J. R. SUTTON	57
RAINFALL AND THE PRESSURE GRADIENT. By J. R. SUTTON	61
COLOUR AND CHEMICAL CONSTITUTION. PART XIV.—THE CALCULATION OF THE COLOUR OF THE DICYCLIC DYES. By JAMES MOIR	65

	PAGE
CRYSTALLINE STRUCTURE OF ANTIMONY AND BISMUTH. By A. OGG. (With two Text-figs.)	75
MAP SHOWING THE DISTRIBUTION OF THE GENUS <i>Agama</i> . By G. A. BOULENGER and J. H. POWER. (Left over from the paper on the subject published in Vol. IX, Part 3)	80
ON THE REPTILIAN GENERA <i>Euparkeria</i> BROOM, AND <i>Mesosuchus</i> WATSON. By S. H. HAUGHTON, B.A. (With Plates II and III)	81
NOTE ON THE PRODUCT OF ANY DETERMINANT AND ITS BORDERED DERIVATIVE. By Sir THOMAS MUIR, LL.D.	89
COMMENTS ON DR. PÉRINGUEY'S NOTE ON WHALES. By ARTHUR F. BEARPARK. (With one Text-fig.)	95
NOTE ON THE PECTORAL FIN OF THE SOLE, <i>Achirus capensis</i> : ITS ORIGIN AND SIGNIFICANCE. By J. D. F. GILCHRIST. (With Plate IV)	99
ON THE SENONIAN AMMONITE FAUNA OF PONDOLAND. By L. F. SPATH, D.Sc., F.G.S. (With Plates V to IX)	113
A FUNGUS— <i>Gibellula Haygarthii</i> , SP. N.—ON A SPIDER OF THE FAMILY LYCOSIDAE. By PAUL A. VAN DER BIJL. (With four Text-figs.)	149
SOME SOUTH AFRICAN STEREUMS. By PAUL A. VAN DER BIJL. (With nine Text-figs.)	151
COLOUR AND CHEMICAL CONSTITUTION. PART XV.—A SYSTEMATIC STUDY OF FLUORESCEIN AND RESORCIN-BENZEINE. By JAMES MOIR	159
THE "ACCOUNT-BOOK" OF JAN HASZING. By C. PIJPER, M.D. (Leiden), Johannesburg, and H. ZWARENSTEIN, M.B., Capetown	165
I. ON SOUTH AFRICAN PARAMPHISTOMIDAE (FISCH.). II. SOME TREMATODES IN SOUTH AFRICAN ANURA, AND THE RELATIONSHIPS AND DISTRIBUTION OF THEIR HOSTS. By C. S. GROBBELAAR, M.A., Lecturer and Demonstrator in the Department of Zoology, University of Stellenbosch, Stellenbosch, S.A. (With nine Text-figs.)	181
STUDIES IN THE MORPHOLOGY OF <i>Selaginella pumila</i> , SPRING. PART I.—THE VEGETATIVE ORGANS OF THE SPOROPHYTE. By A. V. DUTHIE. (With twenty-six Text-figs.)	201
SOME OBSERVATIONS ON THE EFFECTS OF A BUSH FIRE ON THE VEGETATION OF SIGNAL HILL. By MARGARET R. MICHELL, Lecturer in Botany, University of Cape Town. (With Plates X to XII and one Text-fig.)	213

Contents.

v

	PAGE
COLOUR AND CHEMICAL CONSTITUTION. PART XVI.—FURTHER MISCELLANEOUS OBSERVATIONS. By JAMES MOIR	233
ON HYALITE. By J. S. V. D. LINGEN and A. R. E. WALKER	239
CIRCUMCISION REGIMENTS AS A NATIVE CHRONOLOGY. By the Rev. Professor W. A. NORTON, M.A., B.Litt. (With one folding Table)	245
SESUTO AND SECHWANA PRAISES. By the Rev. Professor W. A. NORTON, M.A., B.Litt.	253
NOTE ON A DETERMINANT WITH FACTORS LIKE THOSE OF THE DIFFERENCE-PRODUCT. By Sir THOMAS MUIR, F.R.S.	267
COLOUR AND CHEMICAL CONSTITUTION. PART XVII.—THE AZO DYES AND OTHER MONOCYCLIC COLOURS. By JAMES MOIR	273
FUNGI OF THE STELLENBOSCH DISTRICT AND IMMEDIATE VICINITY. By Dr. P. A. VAN DER BIJL	281
OBSERVATIONS ON THE PROTECTIVE ACTION OF NORMAL SERUM IN EXPERIMENTAL INFECTION WITH BACILLUS DIPHTHERIAE. By T. J. MACKIE, M.D., Ch.B., D.P.H.	289
ON SOME UPPER BEAUFORT THERAPSIDA. By S. H. HAUGHTON, B.A., D.Sc. (With Plate XIII and two Text-figs.)	299



TRANSACTIONS
OF THE
ROYAL SOCIETY OF SOUTH AFRICA.
VOL. X.

THE ACTION OF *EUCOMIS UNDULATA*, AIT.

By J. W. C. GUNN.

(From the Pharmacological Department, University of Cape Town.)

(With three Text-figures.)

Eucomis undulata, Ait, is a bulbous plant of the Natural Order of Liliaceae, which grows in Bechuanaland and Basutoland. It has a local reputation as a cure for galziekte and other diseases in stock. Nothing is known as to its chemical character or pharmacological action. I was given two bulbs, one about 3 in. in diameter and the other much smaller, in order to investigate its constituents and action.

The total amount of material weighed under 200 grm. 100 grm. of the bulb were dried, powdered and macerated in 70 per cent. alcohol for three days, then filtered through three folds of linen. The filtrate was carefully dried over a water-bath. It weighed 10 grm.

ACTION ON THE FROG.

The minimal lethal dose of the extract for frogs was found to be .005 grm. per gramme of body-weight. The extract was dissolved in Ringer's solution and injected into the ventral lymph-sac. Death occurred in from 10 to 26 hours.

The only symptoms noted were slowing of the respiratory movements and final paralysis. The heart was arrested in diastole. There was marked inflammation at the site of injection.

ACTION ON MAMMALS.

(1) *Oral Administration*.—The extract dissolved in water was administered to cats through a stomach-tube. The largest dose given was 6 grm., to a cat weighing 2050 grm. No general symptoms were seen, but evidence

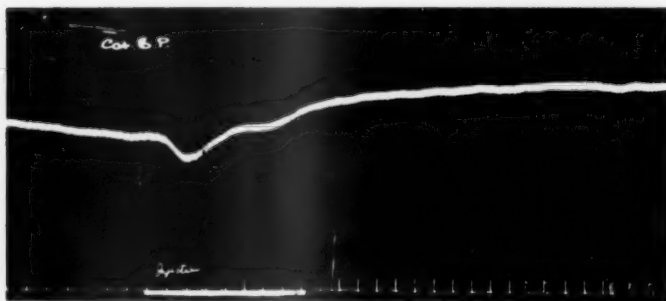
of severe local inflammation, salivation, vomiting and purging were noted in most cases.

(2) *Subcutaneous Administration*.—The extract had only slight toxicity when injected subcutaneously. A dose of 1 gm. per kilo of body-weight produced no general symptoms in rats, and all recovered. The injection was made into the back, near the tail. In almost every case the sciatic nerve on that side became paralysed.

As it was possible that the rat might have some congenital tolerance for the active principle, a similar dose was injected into a cat and a rabbit, but again the effects were purely local.

(3) *Intravenous Injection*.—A tincture, of which 5 c.c. were equivalent to 1 gm. of the bulb, was made with part of the remainder of the material. It was used in the remaining experiments. The alcohol was driven off before

FIG. 1.



it was used. The blood-pressure was recorded, and, as a rule, the respiratory movements, the heart volume, or the intestinal volume as well.

Two main actions were seen: The *heart* was slowed and weakened. If the injection were made very slowly, with a dilute solution, the cardiac effect was lessened or absent. The *blood-vessels* as a rule were constricted. As a result of these actions the effect on the blood-pressure varied. Usually there was a sharp preliminary fall, which seemed to be due to the effect of the substance on the heart. The blood-pressure then rose again, sometimes not quite to its previous level, but sometimes considerably above it. If the injection were made very slowly there was a slight fall or a slight rise. These were the effects seen after injection of 0.5 c.c. of the alcohol-free tincture into the jugular vein of a cat.

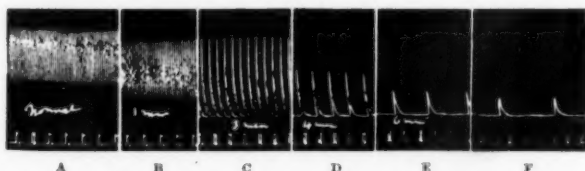
Three cubic centimetres of the tincture, if given in an undivided dose, was fatal, death being due to respiratory failure.

Fig. 1 shows the effect of 0.5 c.c. of tincture of *Eucomis undulata* on the blood-pressure of a cat weighing 2340 gm.

ACTION ON THE ISOLATED HEART.

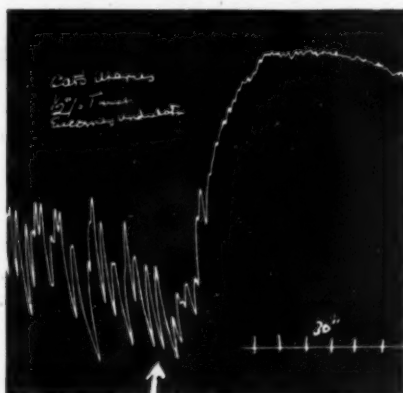
The movements of the isolated mammalian heart were recorded by perfusion through the coronary arteries. The heart of the rabbit, cat, rat and guinea-pig were used. The effect of *Eucomis undulata* was to slow and

FIG. 2.



weaken the heart and arrest it in diastole. In Fig. 2 the effect of 0.5 per cent. tincture is shown on the movements of the cat's heart. A is the normal heart tracing, B, C, D, E and F the movements after perfusing with the experimental solution for 1, 3, 4, 6 and 8 minutes respectively.

FIG. 3.



The isolated frog's heart was arrested in diastole, but sometimes there was a slight increase of tone.

ACTION ON UNSTRIATED MUSCLE.

The tone of the uterus—pregnant and non-pregnant—of the cat and rabbit is increased by *Eucomis undulata*, as shown in Fig. 3.

THE ACTIVE PRINCIPLE.

It was evident that *Eucomia undulata* contained some saponin body, as a very persistent froth was seen when the tincture was shaken up with water.

Forty grammes of the bulb were powdered and extracted with 90 per cent. alcohol. The extract was dried and extracted with distilled water. The resulting extract was dried, and weighed 2.015 gm. It was completely soluble in water and in 90 per cent. alcohol, but insoluble in ether. It produced all the actions of the tincture and extract on animals and isolated tissues.

On boiling with dilute hydrochloric acid a sugar was obtained. The other product of hydrolysis is insoluble in water and is crystalline.

The active principle is, therefore, a glucoside. After the tests and animal experiments were done with it there was not enough left to determine whether it is a pure principle or a mixture. If a small quantity were mixed with water and the mixture shaken a persistent froth formed. Volatile and fixed oils were emulsified with a little of the glucoside, and the emulsion separated out only very slowly.

HAEMOLYTIC ACTION.

The glucoside is powerfully haemolytic. The following table shows its haemolytic action on washed corpuscles in one hour:

Concentration of glucoside.	Result.
1 in 2000	Complete haemolysis.
1 in 4000	" "
1 in 8000	" "
1 in 16,000	" "
1 in 32,000	Partial haemolysis.
1 in 64,000	No haemolysis.
Control	No haemolysis.

SUMMARY.

Eucomia undulata contains a sapo-glucoside which is a powerful haemolytic agent. It does not seem to be absorbed from the alimentary tract, and only slowly from the subcutaneous tissues. It is toxic when injected intravenously, affecting the heart and the respiration. It is probably of no medicinal value.

THE WATER RELATIONS OF THE PINE (*PINUS PINASTER*)
AND THE SILVER TREE (*LEUCADENDRON ARGENTEUM*).*

By R. D. AITKEN, M.Sc.

(Union Government Research Scholar).

Communicated by Prof. D. THODAY.

(With one Text-figure.)

I. INTRODUCTION.

In two papers recently published in the 'Proceedings of the Royal Society,' Farmer (1) has given an account of experiments he has performed with a view to ascertaining, among other matters, whether "the efficiency of the wood can be usefully expressed in a quantitative form, and to what extent separate species differ." As a result of his experiments he concludes that the efficiency of the wood can be thus expressed, and describes a method of measuring it, and defines the "specific conductivity" of the wood as "the quantity of water transmitted through 1 sq. cm. of wood, 15 cm. long, in 15 minutes under a pressure of 30 cm. of mercury."

The clearest result of his experiments is that evergreens possess wood of markedly lower efficiency than that of the broad-leaved deciduous trees, and that the absolute range of variation in individual species is far narrower than in deciduous forms. A few examples from the tables in his papers will illustrate this:

<i>Evergreen.</i>		<i>Deciduous.</i>	
Name.	Spec. cond.	Name.	Spec. cond.
Scots pine . . .	13 ± 2	Common oak . . .	75 ± 15
<i>Euonymus japonica</i> . .	12.1	<i>Euonymus europaeus</i> . .	40.2

He further suggests that the xerophytic character of many of the evergreens may be due to the low conductivity of their wood, and says, "It becomes intelligible why a plant apparently xerophytic may yet be restricted to localities in which it is never really subject to drought. The wood is

* The cost of this research was in part defrayed from a Union Government Research Grant.—D. T.

capable of transmitting a limited supply of water, the leaves are fitted just to utilise this amount with very little margin; in other words, though the plant requires little, it can hardly do with less."

In May of 1919 the present writer began, at the suggestion of Prof. D. Thoday, a series of measurements of the specific conductivity of the wood of certain South African trees with the object of ascertaining whether this property of the wood played any part in deciding the usual habitat of the various trees. It was soon realised, however, that this factor could not be considered independently, but that the transpiring power of the leaves must also be taken into account. For instance, a tree with wood of high specific conductivity and mesophytic leaves, which use up nearly all the water they can obtain from the stem, will probably be quite as much restricted as to its habitat as a tree with wood of low conductivity and xerophytic leaves. Accordingly it was decided to compare the transpiration rates and the water-conducting power of the wood of two trees, and see whether any indication could thus be obtained of the drought-resisting power of the trees.

For the preliminary work the two trees selected were *Pinus pinaster* and *Leucadendron argenteum*, both of which grow within practicable range of the University of Cape Town. The leaves of each of these evergreen trees are distinctly xerophytic. That of the Pine is so well known as to need no description. The leaves of the Silver Tree are sessile, $2\frac{1}{2}$ – $5\frac{1}{2}$ in. long, $\frac{1}{2}$ – $1\frac{1}{4}$ in. broad, and lanceolate. They are densely pubescent on both surfaces with adpressed, silvery, silky hairs. According to Marloth (2) these hairs are closely pressed to the surface of the leaf in dry weather, and stand out at an angle of about 30° from the surface during damp weather. With the naked eye, however, the present writer could observe no difference in the position of the hairs in dry and damp weather, though no critical experiments were conducted to test the statement. As in the case of other Proteaceae the stomata of *Leucadendron argenteum* are protected by a small raised pore.

II. METHODS.

A. *Measurement of conductivity.*—Lengths of 15 cm. were cut under water from the centre of the twigs chosen for the experiments, and placed in jars of water, over which the pressure of air was reduced by means of a suction pump. Half an hour to an hour was deemed sufficient to remove all the air from the stem, and to inject it with water.

To obtain the necessary pressure for the actual conductivity measurements an aspirator was placed on top of a cupboard and filled with distilled water. In order that the pressure might remain constant throughout the series of experiments, a glass tube was inserted through a cork in the top

of the aspirator. A long tube descended from the base of the aspirator, and the twig was attached to the lower end of this tube. In this way a head of water of 186 cm. was obtained. This is equivalent to a pressure of 13.68 cm. of mercury.

The amount of water passing through the twig in 15 minutes under this pressure was measured. The values thus obtained are referred to as the "standard transmission" (i.e. the amount of water transmitted under the standard conditions) of the twigs. In the early experiments four readings were taken for each twig, and it was found that in nearly every case the amount of water transmitted became less with each successive quarter of an-hour, e.g.:

Pine, first	quarter hour, 5.6 c.c.	Silver Tree, 1.6 c.c.
" second	" 4.8 "	" 1.45 "
" third	" 4.0 "	" 1.35 "
" fourth	" 3.1 "	" 1.30 "

That this falling-off was due to clogging at the cut surface seems clear from the facts that it was not nearly so marked in the *Leucadendron* as in the Pine, and that it did not occur when the surfaces were shaved after each reading. The first reading was therefore taken as most nearly representing the true water-conducting power of the wood. In later experiments only one or two readings were taken, and the first of these was used.

Having measured the standard transmission of the twig it was bisected, and a cross-section cut from the centre. By means of a projection apparatus, fitted up at the suggestion of Prof. Thoday from materials available in the laboratory, a drawing of this section was made on squared paper, and the area of wood in the section was measured.

All the data were then available for calculating the specific conductivity of the wood.

B. Measurement of transpiration.—The twigs for these experiments were cut from the trees in the evening and kept overnight with their cut ends in water. They were then placed in small test-tubes of water, and the loss of weight per half hour measured. In some cases the twigs were kept in the laboratory throughout the experiment, in others they were exposed on the roof of the laboratory on both dull and bright days.

C. Measurement of leaf area.—In the case of *Leucadendron* the method was comparatively simple. The leaves were picked from the twig and classified according to their size into about six groups. A representative leaf was then chosen from each group, and placed under glass on a piece of photographic paper. The leaf shape thus obtained was cut out and weighed, and from this weight and the area and weight of the whole piece the area of the leaf print was calculated. Knowing this, and the number of leaves in each group, the leaf area was calculated for each group and then for the whole twig.

Comparison of the leaf area measured in this way with the area calculated from—

Length of leaf \times Total perimeter of mid-section
showed that the latter was always slightly greater than the former, *e. g.*—

No.	<i>a.</i>		<i>b.</i>	
	Area from graph.		Area from Mid-section \times length.	<i>a</i> per cent. of <i>b.</i>
1	7.08 sq. cm.		7.38 sq. cm.	95.9 per cent.
2	6.75 "		7.10 "	95.1 "
3	3.39 "		3.48 "	97.4 "

The actual leaf area was therefore taken to be 96 per cent. of the area calculated from the expression, *perimeter of mid-section \times length*.

To obtain the total leaf area of a twig, the leaves were arranged in groups according to their length, and the diameter of the flat surface of representative leaves from each group measured. The leaf area of each group was then obtained from the expression, *number of leaves \times length \times diam. mid-section \times 2.8 \times 0.96*. As already explained, 2.8 is the value of $(C/D + 1)$ and 0.96 represents the necessary reduction to 96 per cent., just mentioned.

The total leaf area of the twig was then obtained by adding together the areas of the groups.

III. RESULTS.

A. The water-conducting power of the wood.—The first experiments were confined to measurements of the conductivity of the wood of the two trees, and showed a considerable difference between the two. It should be noted that the "conductivity" in these experiments differs from Farmer's "specific conductivity." The former is calculated for a pressure of 186 cm. of water, the latter for a pressure of 30 cm. of mercury. At the outset a few measurements were made of the conductivity of the wood of the Oak as well as of that of the Pine and Silver Tree. The results obtained for these three trees are in accordance with Farmer's main conclusion that evergreens possess wood of markedly lower efficiency than that of the broad-leaved deciduous trees, and that the absolute range of variation in individual species is far narrower than in deciduous forms.

In the few measurements made of the conductivity of the wood of the Oak the values ranged from 18.9 to 107.8, the average of seven experiments being 46.6.

Of the three trees the Pine showed least variation in its conductivity. For the six preliminary measurements with Pine wood the average conductivity was 7.1, the values ranging from 5.9 to 8.2. These measurements were made in July, 1919; in January, 1920, further measurements were

made of both transpiration and conduction, the average conductivity then obtained being 7.9. In the later set of experiments, however, the range of values was greater, the lowest being 5.6 and the highest 9.3. The average conductivity obtained from all the experiments was 7.5.

In the case of the Silver Tree, nine experiments in July gave values ranging from 13.0 to 26.0, the average being 20.8. The January experiments gave lower values ranging from 10.0 to 24.6 with an average of 16.2. The average for all the experiments was 17.8.

These results are tabulated in Table I, in which some of Farmer's figures are included for comparison.

TABLE I.—Measurements of Conductivity.

	Oak.	<i>Pinus pinaster.</i>	<i>Pinus sylvestris.</i>
Range	18.9-107.8	5.6-9.3	—
Conductivity (average) (186 cm. water)	46.6	7.5	—
Specific conductivity (30 cm. mercury):			
Aitken	102.5	16.5	—
Farmer	75 ± 15	—	13 ± 2
	<i>Leucadendron argenteum.</i>	<i>Euonymus japonica</i> (evergreen).	<i>Euonymus europaeus</i> (deciduous).
Range	10.0-26.0	—	—
Conductivity (average) (186 cm. water)	17.8	—	—
Specific conductivity (30 cm. mercury):			
Aitken	39.2	—	—
Farmer	—	12.1	40.2

The present writer's figures show clearly that the wood of the deciduous Oak has a much higher conductivity than has that of the Pine or Silver Tree, and it also gives a larger range of values. This is in accordance with Farmer's main conclusion already quoted.

Comparing the two sets of values for the specific conductivity, a considerable divergence will be noticed in the case of the Oak. This is probably due to the small number of experiments performed by the present writer, for although the average is so much higher, the range of individual values is similar. The specific conductivity of *Pinus pinaster* is only a little greater than that of the species investigated by Farmer. For an evergreen tree *Leucadendron argenteum* has a remarkably high specific conductivity, its value being very nearly equal to that of the deciduous *Euonymus japonica*.

B. *Rate of Transpiration.*—In the experiments on transpiration two objects were kept in view, viz.:

(1) A comparison of the rate of transpiration of similar twigs of the Pine and Silver Tree under the same conditions.

(2) The relation, if any exists, between transpiration and water-conducting power of twigs of the same tree.

With regard to the first of these, all the experiments showed a much higher rate of transpiration both per twig and per unit area of leaf surface in the case of the Pine than of the Silver Tree. In view of the difference in water-conducting power of the wood this result seemed very surprising, but it was obtained under various sets of conditions, *e. g.* in the laboratory, and on the roof of the laboratory, on both dull and bright days. Table II gives the actual transpiration per twig and per unit area of leaf surface of those twigs, the transpiration of which was measured under similar conditions.

TABLE II.—*Transpiration in grammes per hour of Pine and Silver Tree under similar conditions.*

(The experiments bracketed together were concurrent with one another.)

No.	Leucadendron.				Pine.			
	Transpiration per twig		Transpiration per square metre leaf surface.		Transpiration per twig.		Transpiration per square metre leaf surface.	
	Lab.	Roof.	Lab.	Roof.	Lab.	Roof.	Lab.	Roof.
1	1.0	—	—	—	6.2	—	—	—
2	1.54	5.74	5.95	22.25	4.62	14.88	31.9	103.0
3	—	6.54	—	37.5	—	7.1	—	65.2
12	0.41	1.09	3.09	8.2	—	—	—	—
13	0.36	0.90	3.64	9.1	—	—	—	—
14	—	—	—	—	2.26	6.77	16.25	48.67
15	—	—	—	—	2.00	5.81	47.8	139.0
16	0.94	2.05	6.35	13.84	—	—	—	—
17	0.64	1.28	7.23	14.45	—	—	—	—
18	—	—	—	—	1.60	4.37	15.49	42.32
19	—	—	—	—	—	4.47	—	44.87
21	—	1.62	—	15.43	—	—	—	—
27	—	1.20	—	10.07	—	—	—	—
28	—	2.13	—	10.96	—	—	—	—
29	—	—	—	—	—	3.9	—	35.5
30	—	—	—	—	—	6.62	—	38.72

In every case it will be seen that the actual transpiration per Pine twig is greater than that per Leucadendron twig, and that the transpiration per unit leaf area of Pine is greater than that per unit leaf area of Leucadendron.

It will also be noticed in the above table that in concurrent experiments the results for the transpiration per unit leaf area are reasonably concordant in the case of *Leucadendron*, *e.g.* Nos. 12 and 13, 16 and 17, 27 and 28. With the Pine twigs fewer measurements were made, and Experiments 14 and 15 show a considerable divergence in respect of transpiration per unit leaf area.

Two sets of experiments were performed to ascertain whether the high rate of transpiration continued in the Pine as the twigs were allowed to dry. Twigs of both Pine and Silver Tree were kept overnight in water and the following morning the cut ends were blocked with paraffin wax. The loss of weight was then followed in the one set for five hours and in the other for two days. Both sets showed that the rate of loss of the Pine twig was greater than that of the *Leucadendron* during the first two hours, but after this it became less.

Experiments Nos. 20 and 26: Date, January 20, 1920.

No. 20: <i>Leucadendron</i> .			No. 26: Pine		
Time.	Weight of twig.	Loss of weight.	Time.	Weight of twig.	Loss of weight.
9.53 a.m.	37.82 grm.	—	9.57 a.m.	66.54 grm.	—
10.56 "	36.35 "	1.47 grm.	10.59 "	62.90 "	3.64 grm.
11.55 "	35.10 "	1.25 "	11.58 "	59.52 "	3.38 "
12.17 p.m.	34.93 "	0.17 "	12.22 p.m.	59.39 "	0.13 "
1.16 "	34.19 "	0.74 "	1.19 "	59.10 "	0.29 "
2.13 "	33.59 "	0.60 "	2.16 "	58.86 "	0.24 "
3.16 "	32.86 "	0.73 "	3.20 "	58.59 "	0.27 "

Experiment No. 33: Date, January 29, 30, 31, 1920.

No. 33: <i>Leucadendron</i> .			
Date.	Time.	Weight of twig.	Loss of weight.
January 29, 1920	11.6 a.m.	27.46 grm.	—
—	2.4 p.m.	26.69 "	0.77 grm.
" 30 "	9.20 a.m.	23.15 "	3.54 "
" 31 "	9.50 "	17.80 "	5.35 "

No. 33: Pine.			
Date.	Time.	Weight of twig.	Loss of weight.
January 29, 1920.	11.13 a.m.	36.05 grm.	—
—	2.8 p.m.	33.24 "	2.81 grm.
" 30 "	9.24 a.m.	31.57 "	1.67 "
" 31 "	9.54 "	30.17 "	1.40 "

These results are shown in graphical form in the figure on page 17.

In connection with Experiment No. 33 it is to be noted that at the end of the experiment the *Leucadendron* leaves were very dried up, while the Pine needles still appeared fairly fresh. In fact the *Leucadendron* leaves were quite shrivelled up several days before the Pine needles began to die and turn brown.

One or two determinations were made of the water content of fresh leaves, in the hope that this would throw some light on the results of the transpiration experiments. In Experiment No. 3 two twigs, one of *Leucadendron* and one of Pine, were kept in water overnight, and left on the roof of the laboratory with their cut ends in water for about an hour and a half the following morning. At the end of this period the fresh weight of the leaves was determined, and also their area; they were then dried and the dry weight determined. In Experiments Nos. 22 and 24, two twigs were kept overnight in water, and a few leaves were picked from each the following morning. The fresh weight, area, and dry weight of each set were then determined. The result of these experiments was to show that the Pine leaves have a larger water content per square metre of leaf surface than the *Leucadendron* leaves, but a lower water content per cent. of fresh weight.

Experiment No. 3.

	No. 3: <i>Leucadendron</i> .	No. 3: Pine.
Leaf area	1742.8 square cm.	1090 square cm.
Fresh weight of leaves	33.82 gm.	36.45 gm.
Dry " "	14.20 "	18.35 "
Water content " "	19.62 "	18.1 "
Water content per square metre leaf surface	112.6 "	166.1 "
Water content per cent. fresh weight	58.02 per cent.	49.66 per cent.

Experiments Nos. 22 and 24.

	No. 22: <i>Leucadendron</i> .	No. 24: Pine.
Leaf area	173.48 square cm.	115.2 square cm.
Fresh weight of leaves	2.095 gm.	3.145 gm.
Dry " "	1.08 "	1.326 "
Water content " "	1.015 "	1.819 "
Water content per square metre leaf surface	110.4 "	157.9 "
Water content per cent. fresh weight	63.93 per cent.	57.84 per cent.

A number of experiments were also performed with twigs of *Leuca-*

dendron of various thicknesses, but no very definite relation could be discovered between the rate of transpiration, and either the conductivity of the wood, or the area of the wood in cross section. The average of a number of experiments showed, however, that twigs of *Leucadendron* usually bear a larger leaf area per unit cross sectional area of wood than do those of the Pine.

From the results of all the experiments described a table has been compiled to show the relation between the actual transpiration per 15 minutes and the amount of water actually transmitted through 15 cm. of the twig in 15 minutes under the pressure of 186 cm. of water after injection of the wood, *i.e.* between the transpiration and the "standard transmission."

TABLE III.—Relation between Transpiration and "Standard Transmission."

No.	Leucadendron.			Pine.		
	Transpiration.	Transmission.	Transpiration. Transmission.	Transpiration.	Transmission.	Transpiration Transmission.
2	1.44	3.9	0.37	3.72	2.5	1.5
3	1.30	2.9	0.45	1.80	1.8	1.0
4	1.37	2.3	0.60	—	—	—
5	2.50	4.0	0.625	—	—	—
6	1.28	1.5	0.85	—	—	—
10	0.72	0.9	0.80	—	—	—
11	0.68	0.6	1.1	—	—	—
12	0.27	3.2	0.08	—	—	—
13	0.23	1.0	0.23	—	—	—
14	—	—	—	1.69	1.65	1.0
15	—	—	—	1.45	1.2	1.2
19	—	—	—	1.12	0.5	2.2
21	0.41	1.9	0.22	—	—	—
27	0.30	2.7	0.11	—	—	—
28	0.53	3.0	0.18	—	—	—
29	—	—	—	1.00	1.4	0.71
30	—	—	—	1.66	0.9	1.8

(Concurrent experiments are bracketed together.)

In every case it will be noticed that the ratio Transpiration/Transmission is far higher in the Pine than in the Silver Tree. This must mean that the Pine leaves exert a much greater suction force than do the Silver Tree leaves.

IV. DISCUSSION.

For the purposes of discussion it will be convenient to summarise the outstanding results of the above experiments at this point.

The Pine tree possesses wood of very low water-conducting power, but twigs, kept with their cut ends in water, show a high rate of transpiration

both per twig and per unit of leaf area. The Silver Tree, on the other hand, possesses wood of fairly high water-conducting power, its conductivity being rather more than double that of the wood of the Pine, but twigs with their cut ends in water show a much lower rate of transpiration than do similar twigs of the Pine.

When transpiration is followed in twigs, as they dry, it is found that the Pine twigs at first transpire more rapidly than the Silver Tree twigs. After a short time, however, the transpiration of the Pine twigs suddenly drops and becomes less than that of the Silver Tree twigs.

Determinations of water content show that Silver Tree leaves have a greater water content expressed as a percentage of fresh weight than have Pine needles.

Comparing the relation between transpiration and water transmission in the two cases, we find that the ratio transpiration to transmission is far higher in the Pine than in the Silver Tree.

Great caution is necessary in the interpretation of these results owing to the absence of information as to how far experiments with isolated twigs afford a true idea of processes taking place in the intact tree. For instance, the fact that isolated Pine twigs transpire more rapidly than do *Leucadendron* twigs does not enable us to draw any conclusions as to the rate of transpiration of twigs attached to living trees. In all the experiments comparatively short twigs were used, and these were saturated with water overnight. Consequently the resistance to the flow of water to the leaves during transpiration would be minimal, and far lower than when the supply must be drawn from the roots of the tree through the trunk and branches. The measurements of conductivity show that the resistance to the flow of water to the leaves is very much greater in the Pine than in the Silver Tree, and this in itself would tend to lower the rate of transpiration of Pine twigs while attached to the tree.

One conclusion which may safely be drawn is that under the experimental conditions Pine needles exert a greater suction on the water in the stem than do Silver Tree leaves. In experiment No. 2, for example, the "standard transmission" of the twigs was—

Leucadendron 3.9 c.c. Pine 2.5 c.c.

Therefore to force water through the Pine twig at the same rate as through the *Leucadendron* twig would require a pressure or suction 1.56 times as great as that applied to the *Leucadendron* twig. The rate of transpiration of the Pine, however, was 2.58 times as great as that of the *Leucadendron*. Therefore the Pine leaves must have exerted a suction 2.58×1.56 , i.e. about four times as great as the *Leucadendron* leaves. In experiment No. 3 the Pine leaves must have exerted a suction twice as great as the Silver Tree leaves, and in Nos. 13 and 14 four and a half times as great.

One is tempted to infer from this that the greater suction, which our

experiments show can be exerted by the Pine needles, is a response to the structure of the wood, enabling them to obtain water sufficiently rapidly for their requirements. At the same time the much greater tensions, which must exist in Pine trees as compared with Silver Trees, probably neutralise the greater suction force of the Pine needles, so that the transpiration of twigs growing on the tree will probably be less in the case of the Pine than of the Silver Tree. Here, however, it must be remembered that we have no information as to the maximum tensions which the leaves of either tree are capable of exerting or withstanding, and without such information inferences as to the behaviour of twigs on the tree are of little value.

The experiments with drying twigs are suggestive in this connection. The figures for these experiments are repeated in the following table, the initial fresh weight of the twig being called in each case 100. Alongside is given the loss of weight per hour expressed as a percentage of the fresh weight, and the original water content per cent. of fresh weight, as determined in Experiments 3, 22, 24:

TABLE IV.—*Loss of Weight of Drying Twigs.*
Experiments Nos. 20 and 26.

No. 20: Leucadendron.			No. 26: Pine.		
Time.	Weight.	Loss of weight per hour per cent. of fresh weight.	Time.	Weight.	Loss of weight per hour per cent. of fresh weight.
9.53 a.m.	100	—	9.57 a.m.	100	—
10.56 "	96.12	3.7	10.59 "	94.54	5.3
11.55 "	92.81	3.4	11.58 "	89.43	5.2
12.17 p.m.	92.31	—	12.22 p.m.	89.28	—
1.16 "	90.40	1.9	1.19 "	88.82	0.46
2.13 "	88.82	1.7	2.16 "	88.45	0.38
3.16 "	86.90	1.8	3.20 "	88.06	0.43

Experiment No. 33.

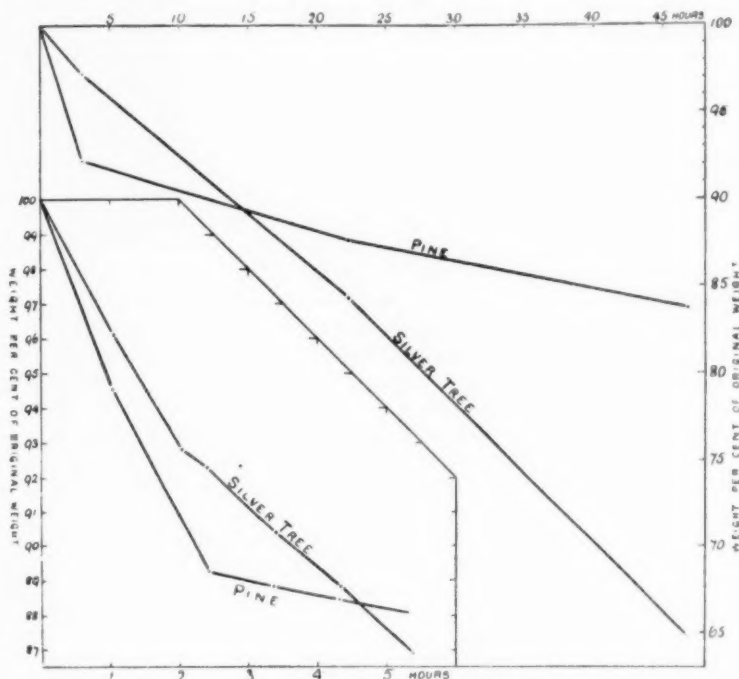
Date.	Leucadendron.			Pine.		
	Time.	Weight.	Loss of weight per hour per cent. of fresh weight.	Time.	Weight.	Loss of weight per hour per cent. of fresh weight.
January 29, 1920	11.6 a.m.	100	—	11.13 a.m.	100	—
"	2.4 p.m.	97.21	0.95	2.8 p.m.	92.19	2.7
" 30 "	9.20 a.m.	84.29	0.67	9.24 a.m.	87.58	0.24
" 31 "	9.50 "	64.82	0.80	9.54 "	83.70	0.16

Water Content per cent. Fresh Weight.

Experiment No. 3, 58.02 per cent. Experiment No. 3, 49.66 per cent.

" " 22, 63.93 " " " 24, 57.84 "

These results are shown in graphical form in the accompanying figure :



The striking difference in the behaviour of twigs of the two trees is that in the Silver Tree the rate of loss does not markedly fall off as the water content diminishes, whereas in the Pine the rate of loss falls after a few hours to less than one-tenth of the rate in the first hour. Tension may be taken to increase as the water content diminishes, unless at some point the resistance of the leaves begins to break down. If this happens the water columns in the vessels break, and the leaves lose water without being able to obtain fresh supplies from the stem. This may be the case with the Silver Tree. In the case of the Pine the bend in the curve suggests either stomatal or internal regulation of a far more drastic nature, and this brings us face to face with another difficulty—the absence of information as to the

behaviour of the stomata, both on the tree and under the experimental conditions.

Attempts were made to obtain this information by Lloyd's method of fixing strips of the epidermis in absolute alcohol, and measuring the size of the stomata and the degree of opening with a micrometer eyepiece. The method, however, proved unsatisfactory, and neither type of leaf is suitable for observations with the porometer.

It is evident, therefore, that any interpretation of the experimental results with reference to the behaviour of whole trees must necessarily be highly speculative. One possible interpretation is that the Silver Tree keeps its stomata only partially open; that it has relatively immobile stomata and that if the conditions become too severe, and the tension exceeds a limited value, the leaves dry back, as in the cut twig. In the Pine, on the other hand, the stomata are more mobile, open wider under favourable conditions, and close more effectively in dry. Another possible interpretation is that there may be a greater power of internal regulation in Pine leaves. That is there may be some way other than stomatal closure, or additional to it, of reducing water loss, probably connected with lowered water content. Apart from these purely speculative suggestions all that can definitely be said at present is that the Pine leaves appear to be more resistant to unfavourable conditions than the Silver Tree leaves.

Further research is needed to determine the effect of cutting on the stomata and internal condition of the leaves. In this connection transpiration measurements in the field are needed, (a) on twigs still attached to the trees, and (b) on twigs immediately after detachment.

Another line of research is the measurement of the actual tensions existing in trees, and hence of the resistances to be overcome by leaves transpiring on the tree.

V. SUMMARY AND CONCLUSIONS.

1. Farmer's experiments on the water-conducting power of the wood of trees have been extended to certain trees growing in the Cape Peninsula, and the results obtained are in general accordance with his conclusions.

2. *Pinus pinaster* has wood of low water-conducting power, its specific conductivity being a little higher than that recorded by Farmer for *P. sylvestris*.

3. *Leucadendron argenteum* has wood of high water-conducting power for an evergreen tree, its specific conductivity being rather more than double that of the Pine.

4. A method of estimating the surface area of Pine leaves is described.

5. Pine twigs, kept with their cut ends in water, show a far higher rate of transpiration, both per twig and per unit leaf area, than do similar twigs of the Silver Tree.

6. The ratio of transpiration to transmission is far higher in the Pine than in the Silver Tree. This is shown to indicate that under the experimental conditions Pine needles exert a greater suction on the water in the stem than do Silver Tree leaves.

7. When transpiration is followed in twigs, as they dry, it is found that the Pine twigs at first transpire more rapidly than the Silver Tree twigs. After a short time, however, the transpiration of Pine twigs suddenly drops and becomes less than that of the Silver Tree twigs.

8. Determinations of water content show that the Silver Tree leaves have a greater water content expressed as a percentage of fresh weight than have Pine needles.

9. The bearing of these results on the water relations of whole trees is discussed, and possible interpretations suggested. It is concluded, however, that all that can definitely be said at present is that the Pine leaves appear to be more resistant to unfavourable conditions than the Silver Tree leaves.

10. Further lines of research are indicated.

In conclusion, I should like to take this opportunity of thanking Prof. Thoday, at whose suggestion the above work was commenced, for his invaluable help and advice throughout the course of the investigation.

I have also to acknowledge the assistance received from the Union Government Research Grant Board, which awarded me a Research Scholarship, thus enabling me to carry out a very large portion of the work described in this paper.

REFERENCES.

1. FARMER, J. B.—'Proc. Roy. Soc.,' 90 B, 218-31, 232-50, 1918.
2. MARLOTH, R.—'The Flora of South Africa,' vol. i, p. 145.

NOTE ON AXISYMMETRIC ORTHOGONANTS.

BY SIR THOMAS MUIR, LL.D., F.R.S.

(1) It will be recalled that Cayley's rule for the construction of a positive unit orthogonant is to take a unit-axial skew determinant, Δ say; replace it by its adjugate; multiply each element of the latter by $2/\Delta$; and then, lastly, from each diagonal element subtract 1. Since the original n -line determinant, taken as it were for material of construction, involves $\frac{1}{2}n(n-1)$ arbitrary constants, this is the number of such constants in the orthogonant.

(2) There is an appreciable advantage to be gained by introducing another constant, a say, the most natural place for it being that of each unit of the original diagonal. The preceding rule then has to have its multiplier $2/\Delta$ changed into $2a/\Delta$, or, what is the same thing, to give place to the following theorem: *If $|a_{1n}|$, or Δ say, be a skew determinant with $a_{11} = a_{22} = \dots = a_{nn} = a$, then*

$$\begin{vmatrix} 2A_{11} - \frac{\Delta}{a} & A_{12} & \dots & A_{1n} \\ A_{21} & 2A_{22} - \frac{\Delta}{a} & \dots & A_{2n} \\ \dots & \dots & \dots & \dots \\ A_{n1} & A_{n2} & \dots & 2A_{nn} - \frac{\Delta}{a} \end{vmatrix}$$

is an orthogonant whose basic constant is $(\Delta/a)^2$. A short verificatory proof is obtained by showing with the help of a result of Spottiswoode's ('Hist.,' ii, pp. 289-291, 315) that

$$\begin{aligned} \text{row}_r \times \text{row}_r &= (\Delta/a)^2 \\ \text{and } \text{row}_r \times \text{row}_s &= 0. \end{aligned}$$

(3) Let us consider now the case of this where n is odd. Δ then, being skew, can be expressed as a sum of terms in descending odd powers of a , so that for Δ/a we have an expression beginning with a^{n-1} and ending with a sum of squares independent of a . If in the result as thus simplified we put $a = 0$, A_{rr} and A_{rr} become equal, being conjugate minors of a zero-axial skew determinant. We consequently obtain when n is odd an axisym-

metric orthogonant involving superficially the full number of arbitrary constants. For example, when n is 3, and

$$\Delta \equiv \begin{vmatrix} a & v & \mu \\ -v & a & \lambda \\ \mu & -\lambda & a \end{vmatrix} = a(a^2 + \lambda^2 + \mu^2 + v^2)$$

we have the axisymmetric orthogonant

$$\begin{vmatrix} \lambda^2 - \mu^2 - v^2 & 2\lambda\mu & 2\lambda v \\ 2\lambda\mu & -\lambda^2 + \mu^2 - v^2 & 2\mu v \\ 2\lambda v & 2\mu v & -\lambda^2 - \mu^2 + v^2 \end{vmatrix}$$

with $(\lambda^2 + \mu^2 + v^2)^2$ for its basic-constant.

(4) The procedure fails when n is even, because then the expansion of Δ has its last term independent of a and cannot be divided by a preparatory to putting $a = 0$. Nevertheless if we introduce the condition that the said last term vanishes, and we so, in effect, diminish the number of arbitrary constants by 1, a result worthy of note is arrived at when n is 4; namely, *If $af + bg + ch = 0$, the axisymmetric determinant*

$$\begin{vmatrix} -a^2 - b^2 - c^2 & 2(bh - cg) & 2(cf - ah) & 2(ag - bf) \\ 2(bh - cg) & -a^2 + b^2 + c^2 & 2(fg - ab) & 2(fh - ac) \\ 2(cf - ah) & 2(fg - ab) & +a^2 - b^2 + c^2 & 2(gh - bc) \\ 2(ag - bf) & 2(fh - ac) & 2(gh - bc) & -a^2 + b^2 - c^2 \end{vmatrix}$$

is an orthogonant whose basic constant is $(a^2 + b^2 + c^2 + f^2 + g^2 + h^2)^2$. What is equally interesting is the fact that this resolves into the product of two orthogonants

$$\begin{vmatrix} . & f - a & g - b & h - c \\ a - f & . & h - c & b - g \\ b - g & c - h & . & f - a \\ c - h & g - b & a - f & . \end{vmatrix}, \begin{vmatrix} . & f + a & g + b & h + c \\ -a - f & . & -h - c & b + g \\ -b - g & c + h & . & -f - a \\ -c - h & -g - b & a + f & . \end{vmatrix}$$

which are both skew and have the same basic-constant

$$a^2 + b^2 + c^2 + f^2 + g^2 + h^2.$$

October 20, 1920.

OBSERVATIONS ON LIVING FISHES BROUGHT BY H.M.S.
 "CHALLENGER" FROM TROPICAL EAST AFRICA TO
 CAPE WATERS.

By J. D. F. GILCHRIST.

The general aspect of the fauna of the warm waters of the southern equatorial current and its branches is very different from that of the colder waters of the circumpolar Antarctic current. This difference is no doubt ultimately due to the differences in the character of these waters as regards temperature and salinity, nitrogen-contents, etc. Waters of such different characters do not readily mix with each other, and, as many animals seem highly sensitive to differences in salinity and temperature either directly or indirectly (through the food supply), an effective barrier to migration is in many cases established. We may therefore divide the marine fauna of the southern hemisphere into two great regions, one which may be called the Equatorial, or the Equatorial-Current Region, and the other the Antarctic, South-Polar, or Antarctic-Current Region. The Equatorial Region is subdivided by the continents projecting into the southern seas, so that we may recognise as divisions of this region the Pacific, Atlantic and Indian sub-regions. These divisions are founded on fundamental physical differences which are clearly seen in the southern hemisphere, but which probably apply in a modified form to the northern hemisphere, where the Polar region is broken up by land masses, which are not found in the South-Polar regions.

Three great regions may therefore be recognised, North Polar, Equatorial, and South Polar, more or less sharply divided from each other, and one of the most interesting problems of zoogeography is the relation of their respective fauna to each other. There is the difficult problem of the resemblance, in some cases identity, of species in the North-Polar and South-Polar regions, on which a diversity of views still exists, and there is the simpler one of the relation of the equatorial fauna to the adjacent polar fauna. These two questions are, however, not unconnected, and it is possible that the more easily ascertained facts in the case of the second may have some bearing on the first.

The South African seas are well adapted for a study of the relation of the Equatorial to the South-Polar regions, and I have already recorded elsewhere some striking facts observed in South African waters in this

connection. These are, briefly, that, at a point on the South Coast, marking the meeting place of the South-Polar and Equatorial waters, there is a mortality amongst fish, and possibly other marine animals, which may be slight or well marked but occurs annually and at definite periods of the year. A similar occurrence is found on the West Coast, at a point in the branch of the South-Polar current which passes up the West Coast of South Africa. The object of the present paper is to record some facts bearing upon this subject from a different point of view.

The H.M.S. "Challenger," namesake of the "Challenger" of zoological fame, arrived in Simons Bay in January, 1919, from British East Africa, Zanzibar and other Eastern ports. She had on board a number of live fish, which had been collected at various places, and kept alive in a tank of circulating water. Dr. N. Spencer Nairne, Surgeon, R.N., who, along with the officers of the ship, were instrumental in securing and keeping the fish alive, readily assented to transfer the fish to the tanks of the Government Marine Laboratory at St. James, near Cape Town, thus affording a unique opportunity of testing the effects of the colder waters of the Cape seas on tropical fish.

The following is a list of the fish, with their localities:

<i>Carnax djeddaba</i>	. Four from Dar es Salaam Harbour.
<i>Carnax affinis</i>	. One from Dar es Salaam Harbour.
<i>Lutianus johnii</i>	. One from Port Amelia, Portuguese E. Africa.
<i>Holocentrum rubrum</i>	. One from Port Amelia, Portuguese E. Africa.
<i>Balistes aculeatus</i>	. One from Mnazi Bay, Portuguese E. Africa.
<i>Epinephelus</i> sp.	. Two from Zanzibar.

The fish were safely transferred in barrels by steam launch and placed together in a large tank (14 x 5 ft.). *Balistes* had, however, to be removed to a separate tank on account of its aggressive habits. The others adapted themselves almost at once to their new surroundings, the two species of *Carnax* swimming about together, the *Epinephelus* (rock-cod) remaining, as is the habit of these fish, under the shelter of the rock-work in the tank.

A marked feature of all the fish was the apparent ease with which they adapted themselves to their new surroundings, and more especially their greater activity as compared with that of the Cape fishes in captivity. The latter feature was more conspicuous in the case of the *Carnax*. Their movements were very rapid and sustained, and it was soon found that no Cape fish of a small size were immune from their attacks. This was specially so in the case of the common Cape mullet (*Mugil capito*), which happened to be in the tank with them.

All of the fish thrived well; they became plumper, and some abrasions, caused doubtless by their confinement in the smaller tank on board the "Challenger," healed up rapidly, and one might wonder why those warm-water fish had not naturally spread to the apparently more congenial con-

ditions of the Cape seas. The reason, however, became apparent at a later date. Up to the 25th of April the four *Carnax* continued active and fed well, but on the 26th, after a strong N.W. wind, the temperature of the water rather suddenly fell to 13° C., and on the 26th three of the fish were found dead in the tank, though apparently quite as usual the day before. The dead fish were carefully examined, and beyond the fact that the skin was covered with an abnormal secretion of mucus all the tissues seemed normal. On the 27th, when the temperature had fallen to 12.5° C., the remaining *Carnax* was found dead under similar conditions.

On the same date the *Lutianus* appeared to be very slow in its movements and it was transferred to another and smaller tank, but soon died.

The most interesting and striking of the fishes was the *Balistes*. It is a gaudily-coloured fish, with body of a salmon-pink colour; three bright blue bands pass from the eye to the base of the pectoral, a yellow stripe from the angle of the mouth, and conspicuous white bands in an oblique direction over the body above the anal fin. The fish had the peculiar habit of retiring at sundown to a particular nook between two rocks, where it lay down on one side and apparently fell asleep, with fins extended and perfectly motionless. If disturbed at night it was aroused with difficulty and usually turned over on the other side and went to sleep again. In the morning it was early awake and swimming about, feeding as actively as before. It was specially fond of crabs. On the onset of the cold weather the fish was found apparently asleep in its corner during parts of the day, and finally, during the whole day through. When aroused it was fairly active and took crabs readily enough. This fish, however, and the *Holocentrum* died shortly after the *Carnax*.

The Rock-cods did not seem to be affected to the same extent. They lived for about a month longer. One was killed by leaping out of the tank and the other died some days afterwards.

There seems little doubt but that the fish, though otherwise well adapted to live in the colder waters, are unable to stand the low temperature of the winter season or perhaps the sudden change of temperature.

It is true that we are here dealing with fish in the artificial surroundings of an aquarium, and this must not be lost sight of in drawing conclusions from this experiment.

Another aspect of the distribution of marine animals on the South African coast is connected with the variation of the strength of the two great conflicting currents which meet in this region, and this, again, is connected with the relative force of the winds which primarily cause the currents. The strong southerly winds of the East Coast have a tendency to check the force of the Mozambique current which flows southward along the East Coast. The absence or diminution of these winds will therefore tend to accelerate the flow of the current of warm water, which will, in that case,

extend further along the South Coast. The Cape fishermen have a great belief in the effect of the prevailing winds (S.E. and N.W.) on the relative abundance and occurrences of fish, and it has been stated that in the marked absence of south-easters in the summer time strange fish are to be found in False Bay and are often cast up dead on the beach. I have examined some of these fish, and they proved to belong to species usually found in the warm waters of the East Coast. A fisherman of many years' experience, on seeing the *Balistes*, stated that he had seen a similar fish cast up on the beach of False Bay.

The fact thus demonstrated that such tropical fish of the East Coast live and thrive for a time in Cape waters would seem to indicate the possibility of their being able to pass the barrier of the Cape and reach the warm waters on the western side of the continent. In these waters, similar in character to those in which they normally live and propagate, they would probably survive and increase, so that we could have identical species on the east and west side of the continent, with an apparent absence of such species in the intervening parts of the ocean.

If some tropical fish can thus run the gauntlet of the colder waters of the Cape and ultimately reach waters in which they can thrive and propagate, it is reasonable to suppose that fish of the northern hemisphere may be able in the same way to pass, in limited numbers and on specially favourable occasions, through warm equatorial waters to the southern hemisphere and *vice versa*. The supposed absence of bi-polar species in the equatorial regions may be only apparent, and they may at special times and on special occasions occur in these regions. The same, of course, holds good for other forms of marine life, more especially, perhaps, of planktonic forms, which may be carried by exceptional currents in limited numbers from their usual haunts, through regions not suited to their increase, to conditions of life not different from their normal environment. Alleged cases of strict bi-polarity in marine animals may, therefore, be more apparent than real.

NOTES ON THE DEVELOPMENT OF THE OVULE, EMBRYO
SAC AND EMBRYO OF *HYDNORA AFRICANA*, THUNB.

By R. H. DASTUR, B.Sc.Bombay, F.L.S.

(With thirteen Text-figures.)

INTRODUCTORY.

The genus *Hydnora* is confined to South Africa, Bourbon and Madagascar, and comprises several species, out of which three only occur in South Africa. They are all parasites, and the species which forms the subject of these notes, viz. *Hydnora Africana*, uses mainly the common milkbush of the karoo, *Euphorbia mauritanica*, L., as its host, and is of fairly common occurrence in South Africa (3). The flowers appear as buds on the underground stem, but soon come above the surface of the ground, and open when mature by means of three longitudinal slits.

The material for this investigation was collected in the neighbourhood of Worcester, Cape Province, mostly by Prof. Saxton in December, 1912, and in part by Mr. Izak Meiring in May, 1912, and fixed in chromacetic acid with or without osmic acid. A short series of sections was prepared by Prof. Saxton, but pressure of other work prevented him from completing the series, and in November, 1919, he handed over the whole material to me. The fixed material consisted mainly of small pieces of the extensive placentas cut out from a series of about a dozen plants ranging from the youngest to the oldest that could be found.

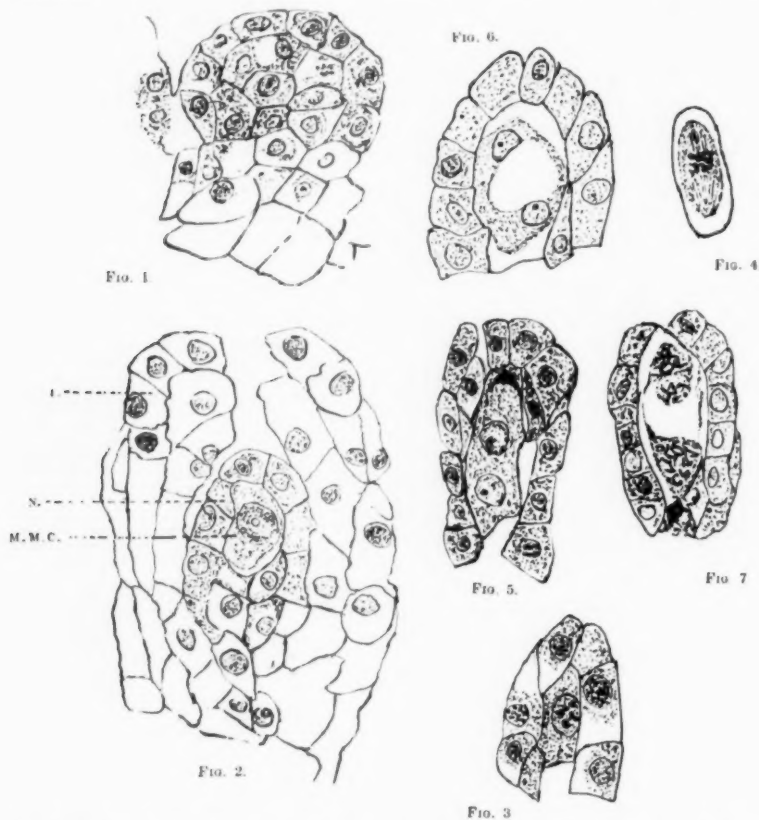
INVESTIGATION.

The placentas are extensive and much branched, and bear radially enormous numbers of orthotropous ovules. The sections were cut, in the main, transverse to the longitudinal axis of the placentas, thus giving longitudinal sections of the ovules in great numbers. A very young ovule before the differentiation of the integument is shown in Fig. 1. Very soon a massive integument makes its appearance, at the top of which the cells divide by periclinal walls giving rise to four layers of cells, while it is only two cells thick on the sides. The very young ovules are nearly spherical but elongate afterwards. No definite archesporial cell or cells are clearly

EXPLANATION OF FIGURES.

All sections were cut with a Cambridge rocking microtome, the thickness varying from 4-7 μ . The figures were drawn with the help of a Leitz microscope and a Zeiss camera lucida. The sections were cut transverse to the placenta, giving longitudinal sections of the ovules.

In all figures: I. Integument; M.M.C. Megaspore mother-cell; N. Nucellus; E.S. Embryo sac; E.C. Egg cell; S.N. Synergid nuclei; P. Polar nuclei; P.T. Pollen tube. M. Male nuclei; A. Antipodal nuclei; E. Embryo; S. Suspensor; P.T.N. Pollen tube nucleus.



FIGS. 1-7.—1. Young ovule about the archesporial stage. $\times 196$. 2. Young ovule showing M.M.C. which directly functions as the embryo sac. $\times 196$. 3. Embryo sac nucleus dividing. $\times 196$. 4. Equatorial arrangement of the chromosomes at the heterotypic division. $\times 196$. 5. The embryo sac with two nuclei, with the curious thickening above. $\times 196$. 6. Embryo sac showing two nuclei with the vacuole. $\times 196$. 7. Division of two nuclei into four. $\times 196$.

recognisable, but a hypodermal cell larger than the rest becomes at once the megaspore mother-cell (Fig. 2). At this stage a curious thickening is seen at the top of the megaspore mother-cell and persists till a later stage.

The megaspore mother-cell functions as an embryo sac directly, without first dividing into four megaspores. The nucleus divides into two by the heterotypic division (Figs. 3 and 4). The sporophyte number of chromosomes is believed to be twenty-four,* and in the reduction division twelve were counted. Vacuoles appear in the embryo sac after the first division and the two nuclei arrange themselves at the poles (Fig. 6). The stages showing the homotypic division of the two nuclei into four were also seen (Fig. 7). Fig. 8 shows the embryo sac with an egg cell nucleus, two synergids, two fusing polars, three antipodals and a pollen tube, with the pollen tube nucleus and two curved male nuclei. Stages were seen in the progress of the polar nuclei towards the centre of the sac, and they fuse before fertilisation (Fig. 8). The antipodals may also disintegrate and disappear before fertilisation. Cases believed to show actual fertilisation were observed, but they have not been figured as the evidence was inconclusive.

The embryo divides into two cells by a transverse wall and transverse divisions continue till a very long chain of cells is formed. As many as fifteen cells were counted in a chain in one proembryo. Then longitudinal divisions occur in about the fifth, sixth, seventh, eighth and ninth cells from the distal end and these cells alone give rise to the embryo proper. The longitudinal divisions begin even before the divisions in the distal part of the filament are complete. The cells of the suspensor slowly shrink and at least the proximal cells disappear gradually, while the distal cells persist in the most mature embryo observed. Fig. 12 shows two longitudinal rows of four and three cells each and Fig. 13 shows two longitudinal rows of five cells each.

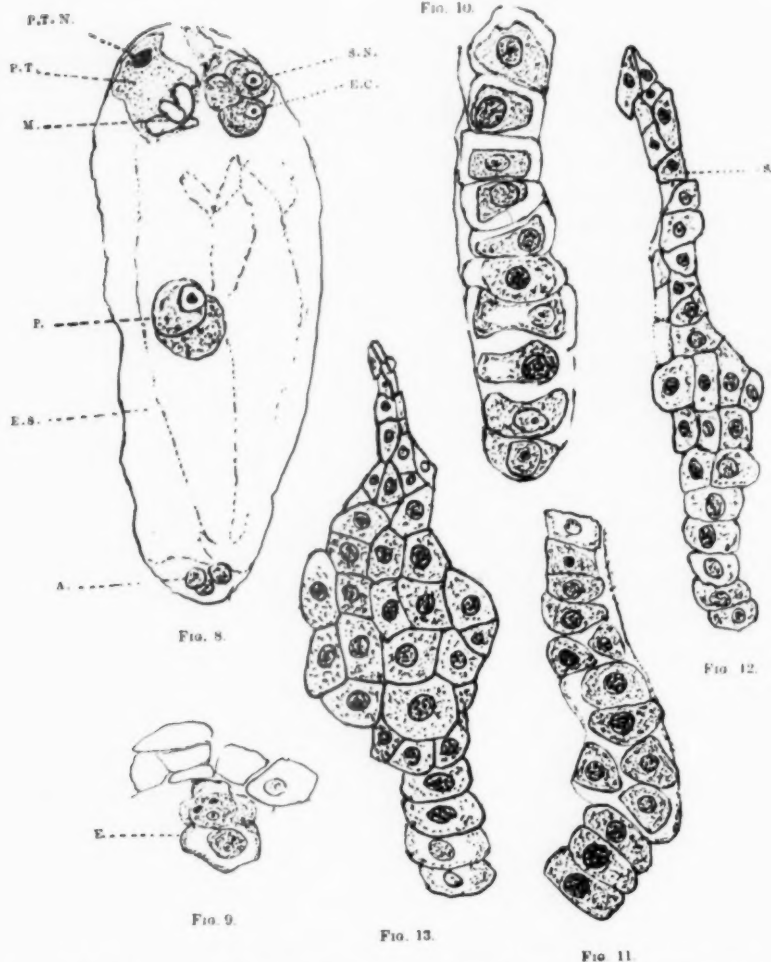
DISCUSSION.

The massive integument seems to be an unusual feature in this species, as generally two integuments prevail among Archychlamydeae, except in some species of Ranunculaceae and Leguminosae (4).

Among Archychlamydeae nearly all the species investigated have three or four megaspores (except in three genera of Piperaceae), and a row of four megaspores seems to be less common than a row of three (4). In this plant the megaspore mother-cell does not divide at all but directly functions as the embryo sac.

The curious thickening which is seen at the top of the megaspore mother-cell, and which persists till a later stage, was thought at first to be the remains of a parietal cell cut off from the archesporial cell, and a careful examina-

* Twenty-three were actually counted, but it is presumed that twenty-four were present.



FIGS. 8-13. Embryo sac showing egg cell nucleus with two synergids, two fusing polars, three antipodals and the pollen tube with a pollen tube nucleus and two male nuclei. $\times 252$. 9. Two-celled embryo. $\times 196$. 10. Older embryo consisting of a chain of cells. $\times 196$. 11 and 12. Beginning of the formation of a massive embryo. $\times 196$. 13. The massive embryo. $\times 196$.

tion of earlier stages was undertaken to test the point. So far as can be ascertained, however, it seems clear that no parietal cell is formed at all.

The long filament of cells produced by transverse divisions from the fertilised egg is unusual among Dicotyledons though paralleled in certain Leguminosae (2). Generally the formation of the embryo proper takes place in the distal cell of the proembryo amongst flowering plants, but in this plant it is approximately in the fifth, sixth, seventh, eighth and ninth cells from the distal cell that the formation of the embryo proceeds. So there are three regions in the proembryo: (1) the suspensor, (2) the embryo proper, and (3) the cells beyond the embryo. The most mature embryo observed (Fig. 13) is still undifferentiated, and the material available does not admit of the investigation of later stages, but field observations indicate that probably these would only be met with in germinating seeds. A small embryo in which neither radicle nor cotyledons are differentiated has been described for a number of parasitic and saprophytic Dicotyledons, but none of them shows an embryo of precisely the same type observed and figured for *Hydnora*. In Engler and Prantl's 'Pflanzenfamilien' (1) there is figured a mature embryo of *Prosopanche Burmeisteri*, De Bary (the only genus allied to *Hydnora*), but the latter does not appear to show the peculiar features described here for *Hydnora*, so far as such features are shown in Solms' figure cited.

In conclusion I have to thank Prof. Saxton for advice, suggestions and criticisms on various points in this investigation. Thanks are also due to Mr. Izak Meiring for his help in the collection of material.

SUMMARY.

- (1) The ovule of *Hydnora* is orthotropous with a single integument.
- (2) The megaspore mother-cell is hypodermal and becomes the embryo sac.
- (3) The proembryo consists of a row of about fifteen cells.
- (4) The embryo is produced from the middle region of the proembryo, and no differentiation had taken place in the latest stages seen (probably from nearly ripe seeds).

Note.—This investigation was carried out in the Botanical Laboratory of the Madhavlal Ranchhodlal Science Institute, Ahmedabad.

LITERATURE CITED.

- (1) SOLMS, H. GRAF ZU.—"Rafflesiaceae" and "Hydnoraceae" in Engler and Prantl, 'Pflanzenfamilien,' III Teil. Ab. 1, 1889.
- (2) GUIGNARD, L.—"Recherches d'embryogénie végétale Comparée. I: Legumineuses," 1881. (In Coulter and Chamberlain's 'Morphology of Angiosperms'.)
- (3) MARLOTH, R.—"Notes on the Morphology and Biology of *Hydnora africana*," 'Trans. S. Afr. Philos. Soc.' vol. xvi, Part v, 1907.
- (4) COULTER AND CHAMBERLAIN.—'Morphology of Angiosperms,' 1912.

(1) THE PERMANGANATE ABSORPTION-SPECTRUM: A CLAIM FOR PRIORITY. (2) A FORMULA FOR CALCULATING THE URANIUM SPECTRUM.

By JAMES MOIR.

(1) In Part VII, Section III, p. 47 of "Colour and Chemical Constitution," published in these Transactions two years ago, I gave the formula— $n = \frac{1}{\lambda} = 1750 + 78 N$ (in which N represents the 7 natural numbers from 0 to 6) by means of which the positions of the 7 absorption-bands of the permanganates in dilute water solution could be calculated.

I now find that an Italian investigator, E. Adinolfi, has practically rediscovered this formula. He states his result as $n = n_3 \pm 75.3 N$, but his n_3 refers to the third (viz. the strongest) band, whereas my figure 1750 refers to the first band. Subtracting therefore 2×75.3 from his value of n_3 (viz. 1902.8)

we get 1752.2. Adinolfi's formula thus reads: $\frac{1}{\lambda} = 1752.2 + 75.3 N$ and

is practically the same as mine, since the decimal points mean nothing in observations of this sort, which are not capable of a higher accuracy than 0.1 per cent. The following table exhibits the results of the calculations:

	Adinolfi's formula.	Moir's formula.	Moir's observations.
Line I	1752	1750	1750
Line II	1827½	1828	1830
Line III	1903	1906	1906
Line IV	1978	1984	1990
Line V	2053	2062	2060
Line VI	2129	2140	2133
Line VII	2204	2218	2204

Adinolfi's observations are in the Journal of the Academy dei Lincei, 1920, and are therefore inaccessible to me, but they apparently do not differ from mine by more than 0.1 per cent. It is probable that the 7 bands are really 10, 3 of which overlap and thus cause the great intensity of II and III, and also the small irregularity of the spacing.

(2) The spectrum of the Uranyl Ion has already been given (*l. c.*, p. 48).

The following formula explains it in mathematical terms, viz. $n = \frac{1}{\lambda} = 2113 + 66 N$ (in which N is 0, 1, 2, 3, and 4):

Calculated: 2113, 2179, 2245, 2311 and 2377.

Observed: 2114, 2180, 2243, 2310 and 2381.

As shown in the same paper the bands of the unionised solid salts can be calculated fairly closely from these figures by dividing by the sixth-root of the ratio of the molecular weight of the salt to that of UO_2^{++} . Thus the bands of autunite are given by—

$$n = \frac{1}{\lambda} = \frac{2113 + 66N}{\sqrt[6]{\frac{914}{2 \times 270}}} = 1937 + 60\frac{1}{2}N$$

Calculated: 1937, 1997, 2058, 2118 and 2179.

Observed: 1945, 2000, 2062, 2128 and 2190.

I wish to thank Mr. T. P. Waites for the fine specimen of autunite in crystals large enough to permit observing the absorption-spectrum.

COLOUR AND CHEMICAL CONSTITUTION.

PART XIII.—THE CALCULATION OF THE COLOUR OF THE MONOCYCLIC DYES.

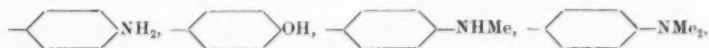
BY JAMES MOIR.

Readers of Part X of this work will remember that by assuming triphenylcarbinol (or its anhydride) to have a potential colour with λ 593 for the position of its absorption-band, I was able to show that the colour of any dye derived from it could be calculated by successive multiplying of λ 593 by factors characteristic of every substituting atom (or group) and position contained in the dye.

Among the simpler members of the family, however, several exceptions were met with. Thus the salts of fuchsimonium or amino-triphenylcarbinol had a calculated $\lambda = 593 \times 0.972 = \lambda$ 576, whereas observation gave the much lower value of about λ 425 (in water). When Part X was written I suggested, as many other writers on colour have also done, that certain substances only exhibit harmonics of their calculated colour. Further experiment has now shown me that this hypothesis is not only unnecessary, but probably quite untrue.

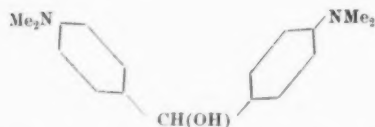
The true explanation is that the scheme described in Part X does *not* apply when the dye is "monocyclic," *i. e.* when it contains only *one* active or ionisable colour-ring. This means that the high colours (between λ 470 and λ 760) of the commercial dyes are in practically every case due to a "dicyclic" constitution, namely, one in which *two* ionisable colour-rings co-operate.

To make my meaning perfectly clear it will be sufficient to give a list of "ionisable colour-rings," viz.:

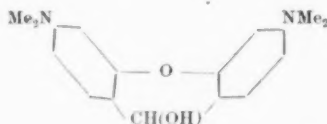


and the other four in which the loose linkage is ortho, not para, to the ionised group. There are no doubt others in which thiophene, furfurane and pyrrole are the rings.

An example of a monocyclic dye is dimethylaminobenzhydrol $\text{Ph} \cdot \text{CH}(\text{OH}) \cdot \text{C}_6\text{H}_4\text{NMe}_2$. Two analogous dicyclic dyes are:



I.—Bis-dimethylaminobenzhydrol. "Michler's hydrol."



II.—Bis-dimethylamino-xanthhydrol. The dye pyronine.

I have now found that the colours of the monocyclic dyes (which, by the way, are all low, viz. below λ 500) can be calculated by a factorial scheme similar to that of Part X, but that the factors are all different from the corresponding factors of the dicyclic scheme.

The parent substance is paraoxybenzylalcohol



(oxyphenylcarbinol), which has a calculated λ of 290 for faintly alkaline water solution. This substance is interesting since its anhydride is the hypothetical quinomethane,



which is the parent-substance of the common "aniline dyes" according to the upholders of the quinonoid theory of colour.

The factors required for colour-calculations are:

- A. Phenyl-factor, for replacement of H in carbinol by Ph = 1.135.
- B. Orthocarboxyl-factor, for conversion of a phenylcarbinol into a phthalein = 1.060.
- C. Phthalein-factor, or factor A \times factor B, for replacing H by $C_6H_4CO_2H$ = 1.203.
- D. Aminocompound-factor, for replacing OH in ring by NH_2 = 1.140.
- E. N-methyl-factor, for replacing H in NH_2 by CH_3 = 1.035.
- F. Methylaminocompound-factor, for replacing OH by $NHMe$ = D \times E = 1.180.
- G. Dimethylaminocompound-factor, for replacing OH by NMe_2 = D \times E² = 1.22.

Armed with these data we proceed to calculate the colours of the known monocyclic coloured substances, and to predict the colours of the unknown or unobserved members of the series.

(1) *Fuchsone*.—This is the diphenyl derivative of the parent-substance. Its calculated λ is therefore $290A^2 = 290 \times 1.135 \times 1.135 = \lambda 374$. Meyer and Fischer observed $\lambda 380$ in alcohol ('Berichte,' 1913, p. 70). Observations in alcohol generally give results about 6 units higher than in water.

(2) *Paraoxybenzhydrol*.—This is the mono-phenyl derivative, and its calculated λ is 329. It has not been observed, but this value is predicted for its colour in alkali. Ortho-oxybenzhydrol is known, and is yellow with λ about 360 ('Beilstein,' ii supplement, p. 694). This is about the usual difference in colour between ortho- and para-compounds, so that the prediction is probably correct.

(3) *Fuchsimine (fuchsone-imine)*.—This is fuchsone with NH_2 in place of OH. The calculated λ is—

$$\left\{ \begin{array}{l} 290 \times 1.135^2 \times \text{factor D} \\ \text{or } 374 \times 1.14 \end{array} \right\} = \lambda 426\frac{1}{2}.$$

Observations by Meyer and Fischer (*l. c.*) gave $\lambda 430$ in alcohol. My own observation, in water, gives $\lambda 425$.

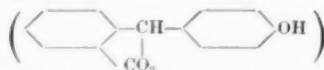
(4) *Fuchsonedimethyliminium salts*.—The calculated value is that of fuchsone multiplied by the factor G, viz. $374 \times 1.22 = \lambda 456$. Meyer and Fischer give $\lambda 460$ in alcohol. My observation in water is $\lambda 455$.

(5) *Mono-oxydiphenylphthalide (phenylphenolphthalein)*.—This is the ortho-carboxylic acid of fuchsone. Its calculated colour corresponds to $\lambda 374 \times 1.060 = \lambda 397$. My observation gives $\lambda 395$ in water.

In Parts I and III of this work I stated that I had observed a pink (instead of a yellow) colour in this substance ($\lambda 560$). This work I now find to be erroneous, for if oxydiphenylphthalide is made from a specimen of benzoylbenzoic acid which has been purified by frequent crystallisation of its ammonium salt (whereby ammonium phthalate is completely eliminated), the product gives a pure yellow in alkali without a trace of the band near 560. The similar compound from salicylic acid (second diagram on p. 125 of Part III) is also wrong: $\lambda 562$ should be $\lambda 420$.

(6) *Phenyl-dimethylaniline phthalein*.—As will be seen by writing out its formula, this is the ortho-carboxylic acid of No. 4 mentioned above. Its calculated colour is therefore that of No. 4 multiplied by 1.06 = $\lambda 483$. The substance is made from benzoylbenzoic acid and dimethylaniline, and my observation of its colour gives $\lambda 480$ for the centre of its absorption band. The unknown phenylanilinephthalein should have $\lambda 452$.

(7) *Para-dimethylaminobenzhydrol*.—This is most simply calculated by multiplying the colour-figure for oxybenzhydrol (No. 2) by factor G. The calculated λ is $329 \times 1.22 = \lambda 401$. Observation in a specimen from benzaldehyd and dimethylaniline gave $\lambda 400$.

(8) *Mono-phenolphthalein*.—

from phenol and phthalaldehydic acid is yellowish and has the calculated $\lambda = 290 \times \text{factor C} = \lambda 349$. This agrees with my observation so far as such can be made, as the centre of the band is just below the limit of visibility, using sunlight.

The number of substances in the monocyclic class is limited, and the remainder are, I believe, all coloured in or near the ultra-violet, and therefore beyond my observation. I therefore predict their colours so that some other observer possessing an adequate photographic apparatus can verify them.

(9) *Para-aminobenzhydrol*.—Calculated $\lambda = 290 \times 1.135 \times 1.14 = \lambda 375$.

(10) *Para-aminobenzyl alcohol*.—Calculated $\lambda = 290 \times 1.14 = \lambda 330\frac{1}{2}$.

(11) *Para-dimethylaminobenzyl alcohol*.—Calculated $\lambda = 290 \times 1.22 = \lambda 354$.

(12) *Para-oxyphthalide*.—

probably has $\lambda = 290 \times 1.06 = \lambda 307$ and so on for the corresponding amino- and dimethylamino-compounds.

It is probably an important point that the parent-substance (whether regarded as quinomethane or as oxybenzylalcohol) has its absorption-band close to those observed for sodium phenate and paracresolate (Baly and Ewbank, 'J.C.S.', 1905, p. 1352), the former being $\lambda 290$, and the latter, calculated to water from alcohol, about $\lambda 285$. The difference is similar to that caused by a methyl-group,* so we can infer that in alkaline water



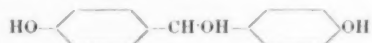
have very nearly the same colour (absorption, speaking more strictly), viz. $\lambda 290$.

It would therefore seem that colour cannot be traced to any lower terms than this, namely, the presence of one benzene ring with one ionisable group, and (usually) another active atom. All the classes of colours except the azo-dyes and certain nitroso-derivatives are therefore accounted for in these terms, so it is probable that the conception of the physical cause of colour as the periodic orbit of an electron round a molecule is the correct one. The sinuous orbit of Part XII is not very likely, but the tautomeric pauses assumed therein are quite a probable feature of the orbit.

It is to be noted that in the dicyclic compounds two rings, each carrying

* Baly and Ewbank's diagram is too small to show the difference.

an ionisable group, always co-operate; consequently the electron-orbit is very much larger and the colours much higher. Part X of this work might therefore be re-written without the hypothesis of fuchsene by making dioxybenzhydrol the parent-substance, whereby on using the dicyclic colour-factors given in Part X, all the colours are calculated without exception, *because the exceptions given there are all monocyclic*. As an example, dioxybenzhydrol



of λ 539 in alkali can be treated with the dicyclic factor 1.059 for NMe_2/OH to give Michler's hydrol (factor applied twice), and so on. This is elaborated in Part XIV.

ON *BRAULA CAECA*, NITZSCH, A DIPTEROUS PARASITE OF THE HONEY BEE.

By S. H. SKAIFE, M.A., M.Sc.

(With eleven Text-figures.)

INTRODUCTION.

Braula caeca is an aberrant dipteran that is a common parasite of the honey bee in this country and other parts of the world. It is a small, active insect, reddish-brown in colour, and about 2 mm. in length (Fig. 1). In strong hives these so-called bee lice rarely become abundant, but in weak colonies they are sometimes so numerous that hardly a bee is without one or more of the parasites. According to Sharp (1) there is only one species known, and this species is placed in a separate family by itself, the *Braulidae*. This family, together with the *Hippoboscidae* and two small and little-known families, the *Streblidae* and the *Nycteribiidae*, make up the series *Pupipara*. *Braula caeca* is linked with the *Pupipara*, mainly because of the statements of Boise, Packard and others concerning its life-history, but, as will be shown later, these statements are erroneous.

Boise states that a pupa is deposited in the cell in the hive by the side of the young larva of the bee, and appears as the perfect insect in about twenty-one days. Packard says that on the day the larva hatches from the egg it sheds its skin and turns to an oval puparium of a dark brown colour. According to Comstock (2) the mode of reproduction of *Braula* is similar to that of the *Hippoboscidae*. Cowan (3) asserts that the "eggs hatch inside the insect and the larvae are nourished by the secretions from a gland. The pupa is extruded on to the floor-board of the hive, and fourteen days later a perfect insect emerges. The young lice remain on the floor-board until they have the opportunity of climbing on to a passing bee."

THE EGGS OF *BRAULA CAECA*.

Some time ago Mr. R. H. Harris, Assistant Entomologist, called the present writer's attention to the fact that certain white specks which are often found on the brood combs in the hives are the eggs of some insect or

other. The writer had often noticed these specks in the hives at Cedara, but had failed to detect their true nature until Mr. Harris suggested that they should be mounted in xylol for examination under the microscope. The xylol dissolves the adherent wax from the white specks, clears them, and renders their examination a simple matter.

The eggs measure about $\cdot 85$ mm. \times $\cdot 56$ mm. and are dead white in colour (Fig. 2). They are oval in shape, and have on either side a flattened wing-like expansion, marked with a delicate, raised reticulation. They seem to be deposited in a haphazard manner over the brood combs, some being

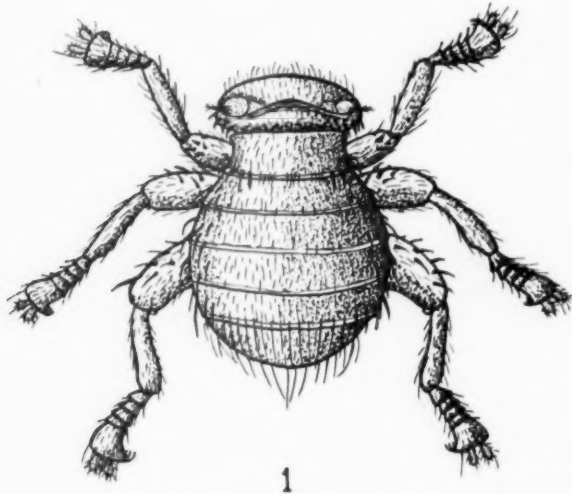


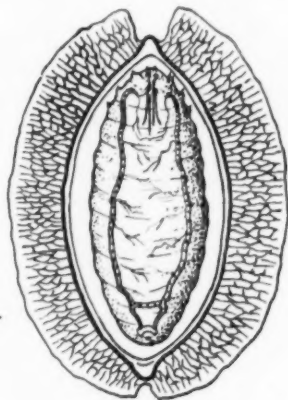
FIG. 1.—*Braula caeca*, Nitzsch. $\times 25$.

placed on the caps of the cells containing sealed brood, others inside empty cells glued to the sides and bottoms of the cells, and still others on the tops of the partitions between the cells. Some of the eggs were found to contain fully developed embryos (Fig. 2) and their dipterous nature was unmistakably revealed. Thus the writer's attention was turned at once to *Braula caeca*, the only dipterous parasite present in the hives. A number of the lice were caught, and carefully dissected under a binocular dissecting microscope. In three or four of the females examined a fully formed egg was found in the common ovarian duct (Fig. 2, *cod*), and these eggs were obviously identical with those found on the brood combs. The appearance, size, shape and markings were exactly identical, so that there could be no possible doubt as to their identity. The characteristic wings with the

reticulations and peculiar notches at either end make the recognition of the eggs easy and certain.

THE LARVA OF BRAULA CAECA.

Having thus established the fact that the bee louse is oviparous and not pupiparous as is so often stated, an endeavour was next made to trace out its life-history. For some time no traces of the immature stages of the parasite could be found in the hives, but finally a neglected hive was found in which the lice were very numerous. This colony had evidently been queenless for some time and was very weak; many laying workers were



2

FIG. 2.—Egg of *Braula caeca*. $\times 70$.

present, and these had given rise to large numbers of drones. Two of the drones from this hive were very badly infested with the parasites, one carrying no less than eighteen of them and the other twelve. Both of the drones were undersized and both had obviously emerged recently.

A number of the drone larvae were removed from their cells and examined under the lens. In several cases one, and in a few cases two, small dipterous larvae were found lying side by side with the bee larvae. The largest of these dipterous larvae measured about 2 mm. in length (Fig. 3). The buccopharyngeal armature, the tracheal system and the sensory papillae of these larvae were exactly similar to those of the embryos found in the eggs of *Braula caeca* (cf. Figs. 2 and 3), hence there could be no doubt but that these were the larvae of the bee louse. The buccopharyngeal armature is of typical muscoidean form, with well-developed

lateral hooks and a large pharyngeal sclerite, but there is no separate intermediate sclerite (Fig. 6). The tracheal system is well developed, metaphneustic, but without the hard, horny spiracular plates usually present in muscid larvae. The larval antennae (Fig. 7, *a*) are small and inconspicuous and of the usual dipterous form. At each end of the larva there are a number of peculiar sensory papillae. Those at the anterior end are long and conspicuous and are armed at the tip with a number of minute blunt cones

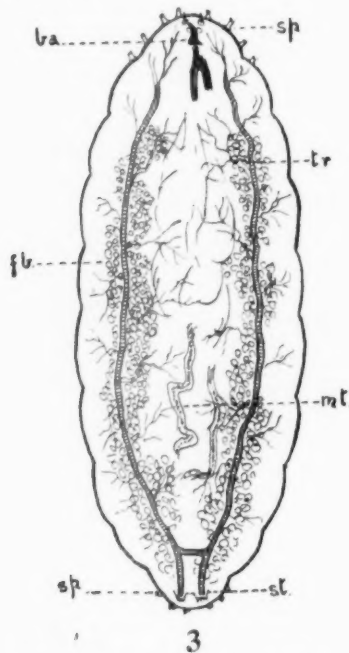


FIG. 3.—Larva of *Braula caeca*.—*sp*. Sensory papillae. *ba*. Buccopharyngeal armature. *tr*. Trachea. *fb*. Fat body. *mt*. Malpighian tube. *st*. Spiracle. $\times 30$.

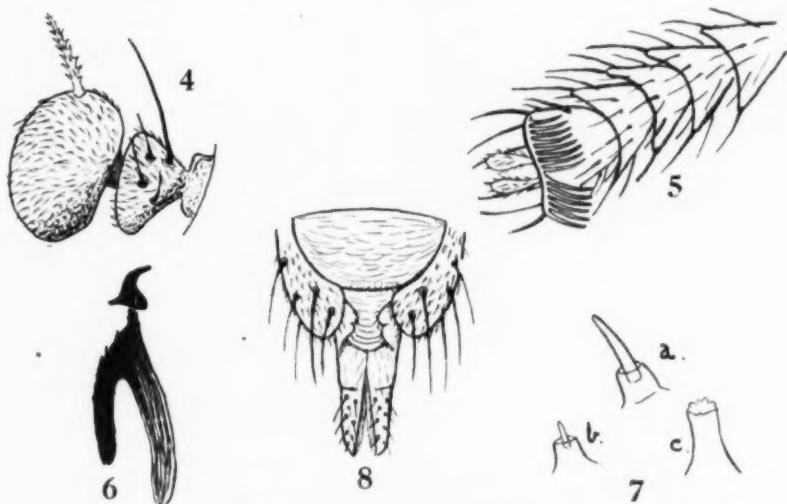
(Fig. 7, *c*), whilst those at the posterior end are shorter and armed each with a single sensory hair (Fig. 7, *b*).

The drone larvae from the cells containing the parasites seemed to be quite normal and healthy. The contents of the alimentary canal of the dipterous larvae were carefully examined and found to consist mainly of pollen, the characteristic pollen grains from the black wattle being especially abundant and easily recognised. The drone larva's stomach was found to contain exactly similar food. Hence there seems little doubt but

that the newly-hatched *Braula* larva makes its way into a cell containing a bee larva, and feeds side by side with it on the food supplied by the nurse bees. Their minute size, white colouring and comparative scarcity in normal hives make their detection very difficult, and would account for their having remained unnoticed hitherto.

THE PUPA OF *BRAULA CAECA*.

Six puparia were brought to light after a prolonged search in the hive mentioned above, and all of these were found in sealed cells containing



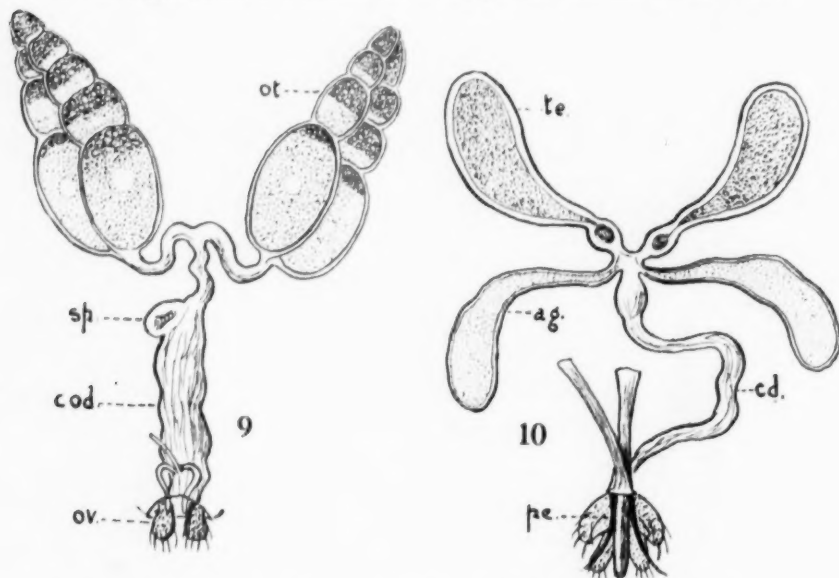
FIGS. 4-8.—4. Antenna of adult. 5. Tarsus of adult. 6. Buccopharyngeal armature of larva. 7. a. Antenna of larva; b. Sensory papilla of larva, anal segments; c. Sensory papilla of larva, anterior segments. 8. Mouthparts of adult.

drone pupae. They were white, oval, about one and a-half millimetres in length, and attached to the sides of the cells. The puparium was found to consist of the last larval skin, not modified or thickened in any way, and the *Braula* pupa could be easily discerned inside. The peculiar sensory papillae (Fig. 7, b and c) and the moulted buccopharyngeal armature (Fig. 6) proved the identity of the puparia and the larvae described above. The adults had already emerged from four of the puparia when found, and these adults, pale yellowish white in colour, had made their way on to the drone pupae inside the cells. The remaining two puparia were kept in order to watch the emergence of the adults, but unfortunately both died soon after their

removal from the hive. The exit hole in the puparium consists of a rough tear and is apparently made by a ptilinum, for a well-marked ptilinal suture can be seen on the head of the adult.

THE ADULT BRAULA CAECA.

The antennae of the adult recall both the muscid and the hippoboscoid types (Fig. 4). They are lodged in deep cavities in the front of the head as in true hippoboscids, and remind one strongly of the antennae of *Melophagus*



FIGS. 9-10.—9. Reproductive organs, female. 10. Reproductive organs, male.
ot. Ovarian tubes. *sp.* Spermatheca. *cod.* Common ovarian duct. *ov.* Ovipositor. *te.* Testis. *ag.* Accessory gland. *cd.* Common ejaculatory duct.
pe. Penis. $\times 45$.

orinus. The mouth-parts (Fig. 8) are peculiar, and do not resemble closely those of the muscid or the hippoboscoid flies; the task of making out the different parts is too involved for the present writer to attempt it. The foot also seems to be unique among the *Diptera*, for the tarsus is armed with two well-developed chitinous combs instead of the two simple claws usual among the *Diptera* (Fig. 5).

The alimentary canal is of the usual type found among the higher *Diptera*. A narrow oesophagus leads to a small proventriculus (Fig. 11), behind which the canal branches, one branch leading into a large, thin-walled

crop, and the other to the chylific ventricle. There are four Malpighian tubes, uniting to form a single pair just before entering the small intestine. The rectal ampulla is large, conspicuous, and furnished with four typical rectal glands, well supplied with trachea. This part of the alimentary canal is strongly reminiscent of that of *Hippobosca*.

The reproductive organs are shown in Figs. 9 and 10 and need little description. There are two ovarian tubules on either side closely applied one to the other. The follicles consist of groups of nurse-cells with a developing ovum posterior to them; the nurse-cells get smaller and the ovum larger as the egg approaches maturity. There is only one spermatheca,

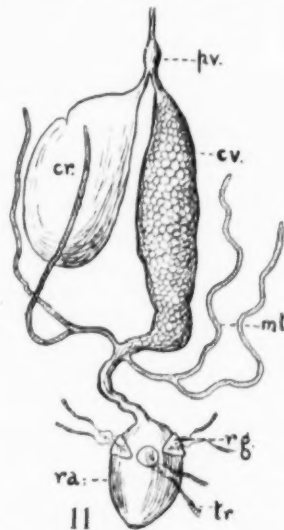


FIG. 11.—Alimentary canal of adult. *pv.* Proventriculus. *cr.* Crop. *cv.* Chylific ventricle. *mt.* Malpighian tubes. *rg.* Rectal glands. *ra.* Rectal ampulla. *tr.* Trachea. $\times 40$.

closely applied to the side of the common ovarian duct—not three as in the true muscids.

The testes are comparatively large sac-like bodies, and there is one pair of accessory glands filled with a white granular fluid. The penis is large and conspicuous and is armed with a pair of strongly chitinised curved spines.

Our knowledge of the feeding habits of the adult is very scanty, and the following, quoted from A. I. Root (4), is perhaps the most authoritative statement so far put forward:

"When the louse wishes to feed it goes to the bee's mouth, where the

motions of its feet, armed with bent claws, produce a tickling sensation perhaps disagreeable to its host, but at least provoking some movement of the buccal organs, which slightly open and release a small drop of honey, which the louse at once licks up."

Although the present writer has never witnessed the feeding of these lice, he has been able to prove that their food consists of honey. In the study of the anatomy of this insect several individuals were dissected which had the crop distended with a colourless fluid, and when this fluid was applied to the tongue it was proved unmistakably to be honey. No solid matter was ever found in the intestine.

SUMMARY AND CONCLUSIONS.

1. *Braula caeca* is oviparous, not pupiparous as was hitherto supposed.
2. The eggs are deposited on the brood combs in the hives, hatch out into typical muscid larvae which make their way into cells containing young bee larvae.
3. The larvae feed on food supplied to the brood by the nurse bees, and beyond robbing the bee larvae of a little of their food do no harm.
4. The larvae pupate inside the cells beside the bee pupae; they emerge before the bees do and make their way at once on to the bodies of their hosts.
5. The adults feed on honey, probably supplied to them by their hosts.
6. Although *Braula* is not pupiparous, it shows many marked resemblances to the *Hippoboscidae*, and the family *Braulidae* should probably be placed between the *Muscidae* and the *Hippoboscidae*, not between the latter and the *Streblidae* as at present.

BIBLIOGRAPHY.

- (1) SHARP, D.—'Cambridge Natural History,' Pt. II, p. 520.
- (2) COMSTOCK, J. H.—'Manual for the Study of Insects,' 1917, p. 459.
- (3) COWAN, T.—'British Bee Keepers' Guide Book.'
- (4) ROOT, A. L.—'A.B.C. and X.Y.Z. of Bee Keeping,' 1919, p. 256.

NOTE ON A FIRE-FLINT OF STRANDLOOPER ORIGIN.

By JOHN HEWITT.

(With Plate I.)

In his important work on the Stone Ages of South Africa, Dr. Péringuey described a remarkable hafted stone implement, found in one of the Outeniqua Caves. He placed the type in his group of South African Neolithic implements, for, having been found along with the skeleton of one of the aboriginal cave-dwellers, it evidently belonged to that race of people variously known as Strandloopers, Coastal Bushmen or Primitive Hottentots.

It is the object of these few notes to give further records of the same type of implement, and to suggest a mode of use.

The earliest reference to the above-mentioned specimen is found in the record of the monthly meeting of the South African Philosophical Society for September, 1892, which reads as follows: "Mr. Péringuey exhibited a stone implement with wooden handle, which was found in a Bushman or Hottentot grave near George. The handle had been attached with some kind of cement, and the implement had been used as a hand weapon." At the December meeting of the Society another note on the same specimen was contributed by Dr. Marloth. His report was as follows: "He had examined the stone implement, and found that the cement used in connecting the handle to the head consisted of resin—probably fine resin and chalk. He had also found starch grains from wheat and rice, which led him to conclude that the natives must have used wheat and rice, and therefore this cement must have been made after the arrival of white men in South Africa."

The account of the discovery by Mr. R. E. Dumbleton, as given in Dr. Péringuey's monograph, contains the following: "On coming to the head (of a human skeleton) I discovered immediately in front of the face two tortoise shells, etc. etc. With these there was the lumbar vertebra of a large ruminant, several flint scrapers, and also a peculiar instrument consisting of a piece of flint fixed in gum-cement, in which was inserted a piece of wood about 4 in. long, serving as handle. The latter unfortunately was perfectly rotten and broke off short."

Another example of this implement but in better state of preservation, has been in the Albany Museum for some years, and a short description was

published in the 'Records of the Albany Museum,' vol. ii, p. 282, and in the Guide Book to the Albany Museum. This specimen also was found in a cave near Plettenberg Bay. The essential features of the implement are—a small piece of chalcedony, roughly trimmed, presenting a concave cutting edge; this is mounted in a large lump of resin, a horn handle with slender and tapering distal end fitting into a comparatively short socket in the resin. The total length of the specimen is $9\frac{1}{2}$ in. There is nothing to suggest a great antiquity for the specimen. The horn handle is well preserved, and, in shaping it, several sharp cuts have been made, which clearly point to the use of a steel or iron blade; it is possible, however, that the present shape of the handle is not as left by the original maker, for whilst the resinous socket is rounded, the socketing portion of the horn has more or less squared surfaces.

Now, what is the function of this unique implement? Dr. Péringuey rightly remarks that "as a serviceable cutting or graving tool it could not prove of much service." He then made the following suggestion: "My first impression was that this hafted tool was that of a ruler or medicine man, somewhat on the lines of the *baton de commandement*, and I am inclined still to look upon it in that light." This explanation seems to me quite untenable, in view of the weak attachment of the handle in our specimen, which would be useless as a baton, or as a weapon, for on moderately rough treatment the lump of resin would break away from the handle. As a cutting implement, on the other hand, it could only be effectively employed when grasped firmly by the resinous lump, the handle being quite free.

The solution of the problem, in my judgment, lies in a suggestion made to me by Mr. Frank Brownlee, who remarked on the strong resemblance in shape between the piece of chalcedony and the imported flints commonly used by the natives of the Eastern Province for striking fire. It could certainly be used as a fire-flint, and, I think, has actually been thus employed, for the cutting edge is worn down in the middle as such flints commonly are. From the fine illustration that accompanies Dr. Péringuey's account I infer that his specimen also has been used in the same way; indeed he says—"The very sinuous edge had been broken before burial probably, as indicated by the comparatively fresh fracture." It may be noted, too, that the stone was actually described by its discoverer as a flint.

Further, the implement as a whole could be utilised as a *combined firelight and torch*, for the resin is very inflammable, and the horny haft would make quite a serviceable handle when thus employed. I cannot positively assert that the resin has actually been burnt since the implement was made, but one point may be stated in favour of this view. It is suggested that the resin originally covered more of the surface of the stone than at present, for the basal portion imbedded in the resinous socket seems

hardly sufficient to afford firm attachment to the stone, however it be used; in its present condition the stone is imperfectly mounted.

The mounting of small chips of quartz or other hard stones in resin or gum-cement seems to have been a practice of Bushmen, and there are several specimens of stone-tipped arrows thus prepared in the South African Museum. Iron, again, has been known to all the South African tribes for centuries, although as a comparative rarity to the Hottentots and Bushmen; its scarcity may perhaps explain the very late adoption of the flint and steel amongst the South African tribes as a whole.

Tinder would have to be used in conjunction with such an implement, but this was no novelty to the aborigines, and indeed is constantly used by the Kalahari Bushmen of the present day along with their fire-sticks. It is true that owing to the brittle nature of the resin a moderate blow on steel would weaken the attachment, and for use in this way the implement would be quite impracticable. To produce fire there is no need to strike a blow; it is sufficient to draw the steel rapidly over the edge of the flint, the latter and its mount of resin being held firmly in the hand.

It may be urged that an easier and more direct way of producing fire was well known to the aborigines, and that Bushmen produce fire by means of fire-sticks with astonishing rapidity. Nevertheless, fire-sticks have their limitations, and in the dreary wet seasons of the Southern Cape Coast the flint and steel may be more reliable. This is indeed just the kind of implement that the coastal cave-dwelling people might be expected to evolve. Moreover, Dr. Péringuey has actually received from the Coldstream Cave what appears to be the steel striker of a tinder-box, and this same cave contained Strandlooper remains.

It is also suggested that the tortoise shells found by Mr. Dumbleton along with the implement were improvised tinder-boxes.

According to the original report, three such shells accompanied the skeleton, but there were no records of tortoise shells from other Strandlooper burial places. In prosecuting his researches, Dr. Péringuey obtained very detailed records of circumstances and accessories from a number of burial sites; indeed, one of his investigators was specially asked to search for more examples of the above-mentioned stone implement and for tortoise shells, but failed to find either, though beads and sundry other objects were taken. Therefore the association of tortoise shells with this unique type of stone implement is probably not accidental. But on this point I do not lay great stress, for at the present day tortoise shells are much used by natives throughout the sub-continent, and for a variety of purposes; they are included amongst the numerous items in the outfit of a Kaffir witch-doctor, and are commonly used by Bush women in Kalahari as powder boxes.

Another specimen of essentially the same type, though differing greatly

in details, has been in our collection for some years, and was referred to by me in the 'Records of Albany Museum,' vol. ii, p. 283. It consists of a limb bone of some bird with a lump of resin at one end. The bone has been marked with incised crosses and transverse lines which perhaps originally served as a tally. The resinous lump expands a little distally, and on one side presents a moderately deep depression, at the base of which is a fragment of hard stone, firmly attached to the resin. This stone cannot be removed for examination without injury to the specimen, but is evidently of flinty nature. It is presumably the broken base of a much larger stone which was formerly mounted in the resin.

The total length of this specimen is 4 in. Thus it is much too small for use as a weapon or baton. It came from the same cave as the first-mentioned specimen, and was no doubt used for a similar purpose. It may have functioned as the striker of a fire-making apparatus and thus can be termed an *aboriginal match*. Lastly, a piece of resin mounted on a stick was found many years ago in a rock shelter at Woest Hill, Grahamstown, along with a number of bones. The resin is a cylindric-ovoid lump about 2 in. long and $\frac{3}{4}$ in. thick; it has a deep socket which still contains decayed wood. There is, however, no indication that this was used as a mount for a stone. It is of interest as additional evidence that the cave-dwelling aborigines made use of resin. Mrs. H. M. Barberton informs me that such resin was quite familiar to the European settlers under the name of "Bushman resin." It was generally believed that the Bushmen employed this material, when available, in the attachment of arrow-heads to the shaft. The chief source of the resin seems to be the roots of *Pterocelastrus variabilis*. Thus obtained, it is very brittle, and for cementing purposes must be mixed with other substances.

Again, in association with typical implements of the Bushman type, there have been found at several inland localities a few worked stones of striking resemblance to fire-flints, though made of local rock. One such specimen, of agate, is in the Albany Museum from Barrow Hill, O.F.S. (Miss Joan Whitworth), and others from Kimberley have been collected by Mr. Jas. Swan and Mr. J. H. Power. But, so far as I know, nothing of this kind has been found under circumstances pointing to great antiquity.

Here it may be added that Sir John Evans, in his work on the 'Ancient Stone Implements of Great Britain,' commented on the resemblance between the modern "strike-a-lights" and the ancient "scrapers," and came to the conclusion that a certain proportion of these latter were in use not for scraping hides but for scraping iron pyrites, and not improbably in later days even iron or steel for procuring fire. He also cited various instances of the occurrence in ancient graves of flint implements in association with nodules of iron pyrites—which for the purpose of producing sparks seems to be as effective as iron.

There is much probability that fire-flints were introduced to the Strandloopers by Europeans. They are mentioned by various writers of past centuries as suitable objects for barter with the natives. John Barrow, referring to some Kaffirs whom he met on the Kareiga River (1797), says: "They received each a small present, consisting of tobacco, knives, flints and steels, tinder-boxes, and a few glass beads. These are the sort of articles which the farmers have been in the habit of exchanging for their valuable breed of cattle."



Strandlooper implements from cave in Plettenberg Bay. $\times \frac{3}{4}$. [In B, only a fragment of the stone remains at the base of the socket of resin.]

A NOTE ON THE USE OF THE SOUTH AFRICAN CLAWED
TOAD IN THE BIOLOGICAL ASSAY OF THE DIGITALIS
SERIES.

By J. W. C. GUNN.

The clawed toad, *Xenopus laevis*, is the most common batrachian in laboratory use in South Africa. Morphologically it is most closely related to the toad, but it is active in its movements like the frog, and there is some evidence that its electrical responses are at least as quick as those of *Rana*.

Vulpian (1) was the first to state, and his observations have been repeatedly confirmed, that the European toad has a considerable degree of natural tolerance for poisons of the digitalis series, the minimal lethal dose for the toad being several times greater than for the frog. Abel and Macht (2) have shown the same to hold true for the tropical toad, *Bufo aqua*.

It is therefore not only of scientific interest to determine whether *Xenopus* reacts to digitalis bodies like *Bufo* or *Rana*, but also of practical importance, since the most convenient method of standardising preparations of digitalis is to determine their toxicity for the frog.

METHOD.

The method employed was that in common use in biological assay of digitalis preparations. A measured quantity of the drug was made up to .5 c.c. with Ringer's solution and injected through the floor of the mouth into the ventral lymph-sac of the toad. Freshly caught animals were used. Either the minimal lethal dose or the amount required to arrest the ventricle in systole in one hour (the minimal systolic dose) was estimated.

The room temperature varied between 21° and 23° C.

MINIMAL LETHAL DOSE OF STROPHANTHIN.

The strophanthin used had been tested on *Rana temporaria* in the Wellcome Physiological Research Laboratories and the minimal lethal dose found to be about 0.0008 mgrm. per gramme weight of frog.

Experiments on *Xenopus laevis*:

Ext.	Dose per gramme of toad.	Time.	Result.
1.	·001 mg.	25 min.	Death.
2.	·0009 "	54 "	"
3.	·0008 "	70 "	"
4.	·0007 "	135 "	"
5.	·0006 "	—	Recovery.
6.	·0005 "	—	"
7.	·0007 "	80 min.	Death.
8.	·0007 "	130 "	"
9.	·0007 "	Overnight.	"
10.	·0007 "	—	Recovery.
11.	·0006 "	—	"
12.	·0006 "	—	"

This would show that the minimal lethal dose of this strophanthin for the toad is ·0007 mgrm. per gramme, practically the same as for *Rana temporaria*.

MINIMAL SYSTOLIC DOSE OF TINCTURES (B.P.).

Two freshly prepared tinctures of digitalis and one of squills were tested by the same method. At the end of one hour the toads were pithed and the condition of the heart examined. The tinctures were known to be active, in two cases by estimating the minimal lethal intravenous dose for cats, and in the other by subsequent clinical trial.

The minimal systolic doses of the tinctures of digitalis were ·0055 c.c. and ·005 c.c. per gramme of toad, and of the tincture of squills ·006 c.c. per gramme. These figures are in close agreement with what would have been expected with *Rana temporaria*, in which an accepted standard of activity of these tinctures is a minimal systolic dose of 0·006 c.c. per gramme.

From these experiments it is concluded that *Xenopus laevis* is as susceptible as *Rana* to the action of the digitalis group, and that it may be used like *Rana* for the biological assay of digitalis preparations, the doses for both being the same.

REFERENCES.

- (1) VULPIAN.—'Compt. Rend. Soc. Biol.,' ser. 2, i, 1854, p. 133.
- (2) ABEL and MACHT.—'Journ. Pharm. Exper. Therap.,' iii, 1912, p. 319.

SUNSPOTS AND EARTH TEMPERATURES.

BY J. R. SUTTON.

Table I gives the results of a comparison between the six-foot earth temperatures observed at Kenilworth (Kimberley) for the nineteen years 1900 to 1918, and the Wolfer's observed sunspot numbers as published in the 'Monthly Weather Review.' The comparison has been made by taking the mean earth temperature of any month and the sunspot number of the previous month: this in order to allow something for the lagging of the earth temperature wave with depth.* The means have then been grouped according to spot numbers below or above thirty. The work was begun more out of curiosity than with the expectation of getting any tangible result; and the direct comparison of curves was not very encouraging. The grouping, on the contrary, shows a somewhat higher temperature for a lower spot number, and that most definitely in the summer half of the year. If the one could be regarded as the direct result of the other this would indicate more intense radiation when the sun is free from spots than at other times. Direct observations of the solar radiation, however, are interpreted to mean less intensity when the sun is free from spots.†

The 1·7-metre earth temperatures observed at Córdoba for the fourteen years 1887 to 1900 have also been compared with the spot numbers in the same way. The results appear in Table II. They are of the same tendency, *i. e.* higher temperatures with fewer spots, though much more pronounced. So also the summer half is the more definite.

Table III refers to the five-foot earth temperatures observed at Adelaide during the thirty years 1878 to 1907. Proximity to the sea may have influenced the temperatures. Only in the summer months is any difference of temperature shown, though that is in the same direction as it is at the other stations.

In all three cases the results, so far as they go, are in agreement with previous ones.

* But no allowance has been made for the lagging in the annual values at the foot of the Table.

† "It seems likely that increased values of the solar constant attend increased sunspot numbers." McAdie, 'The Principles of Aerography,' 1917, p. 276.

TABLE I.—Six-foot Earth Temperatures at Kimberley and corresponding Sunspot Numbers.

Sunspot month.	Earth temperature month.	Sunspot numbers below 30.			Sunspot numbers above 30.		
		Mean of numbers.	Times.	Earth temperatures.	Mean of numbers.	Times.	Earth temperatures.
December .	January .	5.8	9	73.3°F.	55.2	10	72.3°F.
January .	February .	8.4	10	74.5	57.9	9	73.5
February .	March .	8.0	9	74.0	56.3	10	73.6
March .	April .	10.5	10	72.0	60.6	9	72.0
April .	May .	10.0	9	69.4	53.6	10	69.0
May .	June .	9.3	9	65.6	56.1	10	65.2
June .	July .	8.8	10	62.3	62.1	9	62.6
July .	August .	7.3	9	61.5	69.7	10	61.5
August .	September .	8.3	10	62.5	72.2	9	62.5
September .	October .	9.0	9	65.0	63.3	10	65.0
October .	November .	8.6	8	67.9	57.6	11	67.6
November .	December .	5.7	8	70.7	58.9	11	70.3
Summer half .		7.6	53	70.9	58.2	61	70.4
Winter half .		9.0	57	65.6	62.4	57	65.5
Year .		9.0	—	68.2	59.1	—	67.9

TABLE II.—1.7-metre Earth Temperatures at Córdoba and corresponding Sunspot Numbers.

Sunspot month.	Earth temperature month.	Sunspot numbers below 30.			Sunspot numbers above 30.		
		Mean of numbers.	Times.	Earth temperatures.	Mean of numbers.	Times.	Earth temperatures.
December .	January .	11.0	7	20.08°C.	58.0	7	18.93°C.
January .	February .	12.6	8	20.67	60.2	6	19.55
February .	March .	13.0	8	20.72	65.7	6	19.66
March .	April .	11.3	8	19.94	53.2	6	18.89
April .	May .	10.4	8	18.56	65.2	6	18.00
May .	June .	14.5	9	16.97	74.8	5	16.16
June .	July .	12.1	8	15.55	72.0	6	14.95
July .	August .	13.3	8	14.97	70.5	6	14.47
August .	September .	13.7	8	15.34	72.4	6	14.12
September .	October .	9.4	6	16.07	57.8	8	15.10
October .	November .	11.3	8	17.23	63.3	6	15.71
November .	December .	6.9	7	18.83	50.7	7	17.44
Summer half .		10.7	44	18.93	59.3	40	17.73
Winter half .		12.5	48	16.89	68.0	35	16.10
Year .		13.5	—	17.82	62.9	—	16.91

TABLE III.—*Five-foot Earth Temperatures at Adelaide and corresponding Sunspot Numbers.*

Sunspot month.	Earth temperature month.	Sunspot numbers below 30.			Sunspot numbers above 30.		
		Mean of numbers.	Times.	Earth temperatures.	Mean of numbers.	Times.	Earth temperatures.
December .	January .	9.3	15	66.9°F.	55.9	15	66.3°F.
January .	February .	11.5	15	68.2	56.4	15	67.6
February .	March .	13.0	16	67.8	67.7	14	67.8
March .	April .	10.6	14	66.4	55.9	16	66.3
April .	May .	9.0	14	63.9	61.6	16	63.9
May .	June .	12.7	15	61.3	58.1	15	61.3
June .	July .	11.3	14	59.1	61.1	16	59.1
July .	August .	13.0	15	57.9	68.2	15	58.0
August .	September	12.1	14	58.2	59.5	16	58.1
September	October .	10.7	13	59.4	58.2	17	59.3
October .	November	10.7	14	61.8	59.6	16	61.5
November	December	6.6	12	64.2	53.9	18	64.1
Summer half . . .		10.3	85	64.7	58.6	95	64.4
Winter half . . .		11.4	86	61.1	60.7	94	61.1
Year		12.5	—	63.0	57.8	—	62.7

RAINFALL AND THE PRESSURE GRADIENT.

By J. R. SUTTON.

The seasonal rainfall over the greater part of South Africa may be regarded as due mainly to a planetary rain belt following the sun to and fro across the equator. It is this that gives us the summer rains. As the belt moves north it is followed at a distance by the winter rains of the south-west, which, however, do not penetrate often so far inland as the middle reaches of the Orange River, and which recede as the belt returns south. Over the central table-land of South Africa the seasonal rains are very unequal; and the climate is to be regarded in general as a permanently semi-arid one punctuated at occasional intervals by wet years. Why the rainfall varies so much from year to year may be suspected from a consideration of the questions raised by Colonel Rawson in his notable papers on the movements of anticyclones. It appears to depend upon the variations of barometric pressure, or perhaps, rather, upon the causes which produce these. Father Goetz has made an important advance in this aspect of the matter by his discovery of a relationship between the fluctuations of rainfall at Bulawayo and the variations of the second harmonic term in the annual pressure curves.

The present paper is a brief discussion of the possibility that the pressure gradient between Kimberley and Cape Town may have some sort of connection with the rainfall of the two places. For our purpose the monthly means of pressure and rainfall of the two places have been compared for the twelve years 1897 to 1908. The pressure gradient is supposed to be represented month by month by the simple arithmetic difference between the monthly means of pressure at the two places.*

Table I gives the mean gradient, and the mean rainfall of each place for each month of the period. On the whole the gradient is least in autumn (March to May), and greatest in spring (October and November). There is a maximum of rainfall at Cape Town near midwinter, and a secondary maximum near midsummer. The maximum rate of fall at Kimberley occurs in February, the minimum in the late winter, with some tendency to a secondary maximum in July.

Table II shows the mean monthly rainfall of the two places for gradients less than the median ("Small Gradients"), and for those greater ("Large Gradients").

(1) *Cape Town*.—At Cape Town, speaking at large, the rainfall when the gradient is small exceeds that when the gradient is large by about 18 per cent., both summer and winter. Eight months show the excess, four do not.

* *I.e.* at the Royal Observatory, Cape Town, and the Observatory at Kenilworth (Kimberley).

Considering individual months, it happens that of the 88 months having a fall less than the mean, 38 occur with a small gradient and 50 with a large one; whereas of the 56 months having a rainfall greater than the mean, 34 occur with a small gradient and 22 with a large one. That is to say, deficient rainfall tends towards occurrence with months of large, while abundant rainfall tends towards occurrence with months of small gradient.

(2) *Kimberley*.—At Kimberley, on the whole, we have the opposite. The rainfall when the gradient is large exceeds that when the gradient is small by about 15 per cent, the effect being most marked in the winter. Eight months agree, three do not, and one (October) is about neutral. By a coincidence the number of months showing excess or defect is the same as at Cape Town though in the opposite direction like the quantities, *i.e.* of the 88 months having a fall less than the mean, 38 occur with a large gradient and 50 with a small one; whereas of the 56 months having a fall greater than the mean, 34 occur with a large gradient and 22 with a small one.

These facts may be summed up in—

Rule 1.—An excess of rain inclines to occur either at Cape Town or at Kimberley according as the synchronal gradient is small or large respectively.

The question now arises whether this tendency is something more than synchronal: *e.g.* whether it persists at all into the following months? Obviously, by the above Rule, it can only persist at the best to a partial extent; for if the months of small and large gradient were to alternate continually, any persistence would necessarily be masked by the current conditions. But the length of a spell of gradient, large or small, may be anything from one to six months, the average duration being about three. It seemed worth while, therefore, to compare the gradient of each month with the rainfall of the following month. This gives Table III.

The unexpected result shown by Table III is a considerable reversal of the conditions shown by Table II: more rain going to Cape Town and less to Kimberley when the gradient of the previous month was large. With this qualification, that the effect is a winter one at Cape Town, and a summer one at Kimberley. In the summer half at Cape Town and the winter half at Kimberley the normal condition persists into the following month.

Hence we have—

Rule 2.—An excess of rain inclines to occur either at Cape Town in the winter or at Kimberley in the summer according as the gradient of the previous month is large or small respectively.

Rule 3.—At Cape Town in the summer and at Kimberley in the winter the conditions under Rule 1 incline to continue unaltered into the following month.

These results, based on a comparatively short period of observation, can, of course, only be regarded as provisional. As they stand they can only

have a limited use in long-range forecasting. It is to be hoped that the investigation may be carried further, seeing that it promises a certain measure of information beyond the mere requirements of weather prediction. As Lord Rayleigh, thirty years ago, truly said, "In order to introduce greater precision into our ideas respecting the behaviour of the earth's atmosphere, it seems advisable to solve any problems that may present themselves."

TABLE I.—*Monthly mean Pressure Gradients and Rainfall.*

	Gradient. in.	Rainfall. Cape Town. in.	Rainfall. Kimberley. in.
January	3·864	1·11	3·09
February	3·848	·46	2·85
March	3·828	·74	3·06
April	3·838	2·29	1·57
May	3·832	3·98	·56
June	3·843	4·33	·26
July	3·845	3·60	·30
August	3·866	3·22	·11
September	3·895	2·27	·88
October	3·914	2·27	1·17
November	3·918	·90	1·53
December	3·889	·94	2·06
Year	3·865	26·11	17·44

TABLE II.—*Monthly mean Rainfall corresponding to Synchronal Gradients Greater or Less than the Median.*

	Rainfall. Cape Town.		Rainfall. Kimberley.	
	Small gradient. in.	Large gradient. in.	Small gradient. in.	Large gradient. in.
January	·87	1·34	3·90	2·28
February	·68	·25	2·72	2·98
March	·81	·67	2·26	3·87
April	2·20	2·39	1·47	1·67
May	3·45	4·51	·32	·79
June	5·67	2·99	·10	·42
July	4·53	2·66	·45	·14
August	3·30	3·14	·07	·14
September	2·11	2·43	·25	1·51
October	2·36	1·92	1·16	1·13
November	·99	·81	1·63	1·43
December	1·11	·77	1·87	2·26
Summer Half	6·82	5·76	13·54	13·95
Winter Half	21·26	18·12	2·66	4·67
Year	28·08	23·88	16·20	18·62

TABLE III.—*Monthly mean Rainfall corresponding to Gradients of the Previous Month Greater or Less than the Median.*

Rain Month.	Rainfall. Cape Town.		Rainfall. Kimberley.	
	Small gradient. in.	Large gradient. in.	Small gradient. in.	Large gradient. in.
January .	1·24	·79	3·88	2·49
February .	·42	·50	3·24	2·47
March .	·75	·73	3·30	2·83
April .	2·47	2·12	·90	2·24
May .	3·43	4·52	·62	·49
June .	2·82	5·77	·42	·09
July .	3·41	3·78	·03	·56
August .	3·79	2·64	·12	·10
September .	1·94	2·59	·62	1·13
October .	2·38	2·17	1·06	1·27
November .	1·01	·95	1·27	1·42
December .	1·10	·78	2·33	1·80
Summer Half	6·90	5·92	15·08	12·28
Winter Half	17·86	21·42	2·71	4·61
Year	24·76	27·34	17·79	16·89

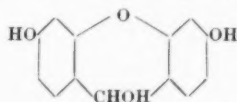
COLOUR AND CHEMICAL CONSTITUTION.

PART XIV.—THE CALCULATION OF THE COLOUR OF THE DICYCLIC DYES.

BY JAMES MOIR.

The remarkable discovery published last year in the *Addendum* to Part X, whereby I was enabled to calculate the colour of methylene-blue from that of a dye containing neither nitrogen nor sulphur, has in the meantime proved very fertile. I have now worked out all the factors whereby the colour of any dye made up of two ionisable rings and either one or two linkages can be calculated. This means calculating quite two-thirds of the known dyes.

Dioxybenzhydrol, $\text{HO} \cdot \text{C}_6\text{H}_4 \cdot \text{CH}(\text{OH}) \cdot \text{C}_6\text{H}_4\text{OH}$ is an example of a singly-linked dicyclic dye, and dioxy-xanthhydrol



is an example of a doubly-linked dicyclic dye. Mono-oxybenzhydrol on the other hand is "monocyclic," having only one ionisable ring.

I find if the assumption is made that the wave-length of an electron-orbit going round *two* phenol rings is about λ 1380, that this orbit is *contracted* by linkage of the rings *always in the same proportion for the same linkage, whatever other groups are present*. Each linkage thus has a colour-factor (less than unity) which, when multiplied by 1380, gives the colour of the corresponding di-oxyphenyl-dye.

Table of Linkage Factors.

A. Methylene or	$\diagup \text{CH}_2 \diagdown$	.	.	.	Value 0.65.
B. Imino	or $\diagup \text{NH} \diagdown$	.	.	.	Value 0.78.
C. Oxo-	or $\diagup \text{O} \diagdown$	.	.	.	Value 0.89.
D. Thio-	or $\diagup \text{S} \diagdown$	.	.	.	Value 0.92.

If *two* of the linkages are present in a phenolic dye, the figure 1380 is to be multiplied by *both* factors.

I have also discovered that the effect of oxidising the linkage is always the same whatever the linkage is. The effect is to make the factor of the oxidised linkage exactly $\frac{2}{3}$ of the factor of the unoxidised linkage.* This may be due, as explained in Part XII, to changing from five tautomerisms to three only.

Table of Factors for Oxidised Linkages.

E. Oxymethylene or carbinol linkage, $\diagup \text{CHOH} \diagdown$	Value 0.39
F. Dioxymethylene or keto linkage, $\diagup \text{CO} \diagdown$	Value 0.234
G. Oximino or hydroxylamine linkage, $\diagup \text{NOH} \diagdown$	Value 0.47
H. Peroxide linkage, $\diagup \overset{\text{O}}{\underset{\cdot\cdot}{\text{O}}} \diagdown$	Value 0.535
I. Sulphoxide linkage, $\diagup \text{SO} \diagdown$	Value 0.55
J. Sulphone linkage, $\diagup \text{SO}_2 \diagdown$	Value 0.33 (?)
[K. Trebly-linked carbinol, $\equiv \text{COH}$	Value 0.386]

These are all the *new* data required for the calculations, but in addition all of the 27 ring-colour-factors published in Part X may be used so as to extend the theory from the phenolic dyes to all sorts of classes of dicyclic dyes. Thus, for bis-dimethylamino dyes the figure for the corresponding phenolic dye is to be multiplied by the square of 1.059, the factor for replacement of OH by NMe₂ (Part X, p. 306, middle), or alternatively, instead of λ 1380, use λ $1380 \times (1.059)^2 = \lambda$ 1548 for the fundamental vibration round two dimethylaniline rings. Similarly the fundamental vibration for *two* aniline rings is λ $1380 \times \left(\frac{0.972}{0.9657}\right)^2$ or λ 1400 (Part X, p. 304).

According to this theory the colour of the majority of the *singly-linked* dicyclic substances, such as dioxydiphenylmethane, is in the infra-red: those which are observable to the eye are calculated below.

(1) *Dioxybenzhydrol* (formula on p. 65).—The calculated λ is $1380 \times \text{factor E} = 1380 \times 0.39 = \lambda$ 538. Observed λ 539.

(2) *Benzaurine* (di-para-variety).—This is the C-phenyl derivative of the foregoing. The C-phenyl factor is 1.026 (Part X, p. 310). Calculated $\lambda = 1380 \times 0.39 \times 1.026 = \lambda$ 552. Observed λ 553.

(3) *Michler's hydrol*.—This is two dimethylaniline rings joined by CHO. Calculated $\lambda = 1548 \times 0.39 = \lambda$ 604. Observed λ 603.

(4) *Malachite green*.—This is the C-phenyl derivative of No. 3. Calculated $\lambda = 1548 \times 0.39 \times 1.026 = \lambda$ 620. Observed λ 619.

* Watson and Meek first showed this to be the case for the CO group.

(5) *Doebner's violet*.—This is No. 4 less four methyl groups. Calculated $\lambda = 1400$ (see 15 lines above) $\times 0.39 \times 1.026 = \lambda 561$. Observed $\lambda 562$.

(6) *Aurine*.—Here the linkage K is used instead of linkage E, although they are nearly the same. As shown in Part XII, p. 209, only two of the three rings act in producing the colour. The calculated λ is $1380 \times 0.386 = \lambda 533$. Observed $\lambda 534$.

(7) *Fuchsine (para)*.—Two aniline rings and the factor K are used. Calculated $\lambda = 1400 \times 0.386 = \lambda 541$. Observed $\lambda 543$. Commercial fuchsine has an extra C-methyl group and has $\lambda 549$. Calculated, using the C-methyl factor $1.012 = \lambda 547$.

(8) *Crystal violet*.—Two dimethylaniline rings and factor K to be used. Calculated $1548 \times 0.386 = \lambda 597$. Observed $\lambda 595$.

(9) *Aniline blue*.—Two diphenylamine groups and the factor K to be used. The N-phenyl factor has twice the effect of the C-phenyl factor (cf. ortho- and meta- groups in Part IV, p. 188). Its value is therefore $(1.026)^2 = 1.054$. Hence two diphenylamine groups have the value $\lambda 1400 \times (1.054)^2 = \lambda 1554$, and the calculated value for aniline blue is $1554 \times 0.386 = \lambda 599$. Observed $\lambda 600$.

(10) *Phenolphthalein*.—This is No. 1 with a benzoic acid group attached. The factor for the latter is C-phenyl multiplied by o-carboxyl (see Part X, p. 306) $= 1.026 \times 1.002 = 1.028$. Calculated λ for phenolphthalein $= 1380 \times 0.39 \times 1.028 = \lambda 553$. Observed $\lambda 554$.

(11) *Phenolsulphonophthalein*.—This is No. 1 plus a benzenesulphonic acid group. The latter's factor is 1.026×1.018 (Part X, p. 308) $= 1.045$. The calculated λ is $1380 \times 0.39 \times 1.045 = \lambda 562$. Observed $\lambda 563$.

(12) *Michler's ketone*.—Two dimethylaniline rings and the factor F are to be used. Calculated $\lambda 1548 \times 0.234 = \lambda 362$. Observed $\lambda 364$.

(13) *Indophenol*.—This is the anhydride of dioxy-diphenylhydroxylamine.* Two phenol rings and the factor G are therefore to be used. Calculated $\lambda = 1380 \times 0.47 = \lambda 649$. Observed $\lambda 650$.

(14) *Indamine*.—This in the same way is derived from two aniline rings and the factor G. Calculated $\lambda = 1400 \times 0.47 = \lambda 658$. Observed $\lambda 660$.

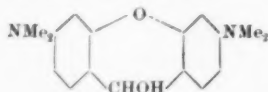
(15) *Bindscheller's green*.—This is tetramethylindamine, and the calculation requires two dimethylaniline rings and the factor G $= \lambda 1548 \times 0.47 = \lambda 728$. Observed $\lambda 730$.

Doubly-Linked Dicyclic Colours.

Of these there is an enormous number in use, varying from eosine to safranine and methylene-blue. If all the ten factors were used two at a time there would be 100 colours of each of the three classes, viz. phenols, anilines and dimethylanilines. I therefore limit myself to those I have observed, or for which data exist in the literature.

* Commercial "indophenol" is a naphthol compound.

(16) *Pyronine*.—This has the formula :



It is calculated by multiplying λ 1548 (for the dimethylaniline rings) by factors C and E, viz. $1548 \times 0.89 \times 0.39 = \lambda$ 536. Observed λ 542 in alcohol.

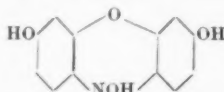
(17) *Rhodamine*.—This is the benzoic-acid derivative of pyronine (cf. phenolphthalein). The benzoic factor is 1.028 (see p. 67). The calculated λ is $536 \times 1.028 = \lambda$ 552. Observed λ 553.

(18) *Dioxyxanthhydrol*.—This is pyronine with 2OH instead of 2NMe₂. Calculated $1380 \times 0.89 \times 0.39 = \lambda$ 478. Observed λ 479. This substance is the parent of fluorescein.

(19) *Fluorescein*.—The above plus benzoic acid is fluorescein. Calculated $478 \times 1.028 = \lambda$ 492. Observed λ 494.

(20) *Eosine*.—This is fluorescein plus four ortho-bromines. Calculated $\lambda = 492 \times (1.0128)^4$ (see Part IX) = λ 519. Observed λ 521.

(21) *Resorufine*.—This has the formula :

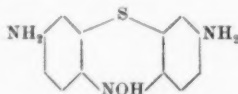


λ 1380 for the phenol rings is therefore multiplied by factors C and G. The result is $1380 \times 0.89 \times 0.47 = \lambda$ 577. Observed λ 576.

(22) *Thionol*.—This is the foregoing with S in place of O. The calculated value is $1380 \times 0.92 \times 0.47 = \lambda$ 597. Observed $\lambda = 593$.

(23) *Methylene-blue*.—This is the example given in the *Addendum* to Part X. It is thionol with two dimethylaniline rings instead of two phenol rings. Calculated $1548 \times 0.92 \times 0.47 = \lambda$ 668. Observed λ 665. Formánek gives λ 667½ in what was probably a better specimen.

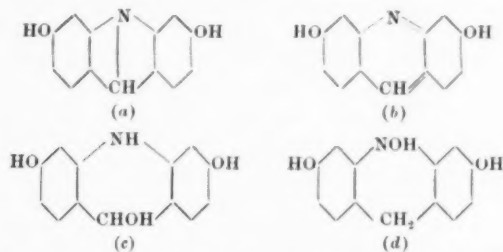
(24) *Thionine*.—This has the formula :



Calculated value = 1400 (for two aniline rings) $\times 0.92 \times 0.47 = \lambda$ 604. Observed λ 603.

(25) *Gentianine*.—This is halfway between Nos. 23 and 24 in constitution. Since the scheme is factorial its calculated λ is the geometric mean (not the arithmetical mean) of the λ of Nos. 23 and 24 = λ 635. Formánek observed λ 638.

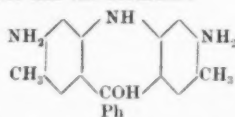
(26) *Dioxyacridine*.—This can be written in four ways and calculated from either of the hydrated forms, viz.:



According to formula (c) it is dioxybenzhydrol with the NH linkage: calculated $1380 \times 0.39 \times 0.78 = \lambda 420$.

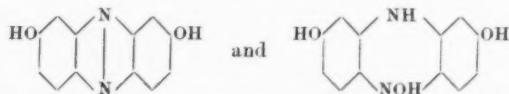
According to formula (d) the calculation is $1380 \times 0.65 \times 0.47 = \lambda 422$. The difference is due merely to the factors not yet being accurately known to three places of decimals. Observed $\lambda 421$.

(27) *Benzoflavine*.—This has the formula:



The calculation involves $\lambda 1400$ for the two aniline rings, multiplied by (a) the CHOH factor, (b) the NH factor, (c) the phenyl factor, (d) the square of the orthomethyl factor (see example No. 7). The calculated value is $1400 \times 0.39 \times 0.78 \times 1.026 \times (1.012)^2 = \lambda 449$. The observed value was about $\lambda 454$.

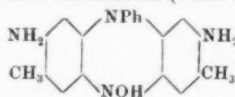
(28) *Dioxyphenazine*.—This, being symmetrical, has only two formulæ, viz.:



Its calculated λ is $1380 \times 0.78 \times 0.47 = \lambda 506$. Observed $\lambda 510$.

(29) *Neutral red*.—This is dimethyldiamino-toluphenazine. The parent rings are one aniline and one dimethylaniline ring, the value of which (see No. 25) is $\sqrt{1400 \times 1548} = \lambda 1473$. This is to be multiplied by the NH and NOH factors and by 1.012 for the ortho-methyl group (see No. 27). Calculated $\lambda 546$. Observed $\lambda 540$ (commercial specimen).

(30) *Safranine*.—This has the formula (when hydrated):

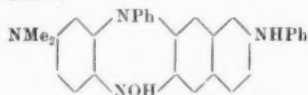


Calculated $\lambda = 1400 \times 0.78 \times 0.47 \times 1.026$ (for phenyl) $\times (1.012)^2$ (= benzo-flavine $\times 0.47 \div 0.39$) = $\lambda 541$. Observations in commercial specimens vary between $\lambda 530$ and $\lambda 540$; probably some do not contain the methyl groups.

(31) *Methylene violet*.—This is isomeric with safranine, but the two methyls are on nitrogen not in the ring. Calculated $\lambda 473$ (see No. 29) $\times 0.39 \times 0.78 \times 1.026 = \lambda 554$. Commercial specimens vary in observation between $\lambda 550$ and $\lambda 565$, being mixtures. Another way of calculating this isomeric substance is to note that the N-methyl group has twice the effect of the C-methyl group, the latter having a factor of 1.012; the former has a factor of $(1.012)^2 = 1.0245$ (see Part X, p. 305). Consequently No. 31 calculated from No. 30 is $\lambda 541 \times (1.0245)^2 \div (1.012)^2 = \lambda 541 \times (1.012)^2 = \lambda 554$. This doubling of effect on changing from C-substitution to N-substitution has already been mentioned under substance No. 9, but it is to be noted that phenyl (and probably methyl also) on a linkage has always the value 1.026 whether on C or on N.

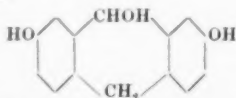
(32) *Magdala red*.—This is safranine with two naphthalene-rings attached, and a third in the linkage instead of phenyl. The calculated colour of phenyldiaminophenazonium salts is $\lambda 527$, whereas Magdala red shows $\lambda 559$. Assuming that the linkage-naphthyl has the same effect as phenyl, this gives a factor of 1.030 for the naphthalene-ring residues, each $C_{10}H_7$. This is a much smaller value than that found from the naphtholphthaleins (1.092), and remains an anomaly until further work can be done on naphthalene colours in general.*

(33) *Azine green*.—This is about the most complicated member of the series. It has the formula:



As shown under No. 32, phenyldiaminophenazonium has $\lambda 527$. Azine-green has, in addition to the latter, a naphthalene-ring, two N-methyls and one N-phenyl (value 1.054). Assuming naphthalene to have the normal value of 1.09, because the amino group is *outside* it in this case, the calculated colour of azine-green is $527 \times (1.0245)^2 \times 1.054 \times 1.09 = \lambda 636$. I have not observed it, but the description in the literature indicates that the observed value lies between $\lambda 620$ and $\lambda 640$.

(34) *Dioxyanthracene*.—The ordinary formula of this substance when written hydrated becomes:



* Since this was written it has been discovered that naphtholphthalein has ortho linkages instead of para as hitherto supposed. There is thus no anomaly after all.

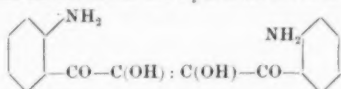
The calculated colour is $1380 \times 0.65 \times 0.39 = \lambda 350$. It is described in 'Beilstein' as pale yellow, which agrees with the calculation. Dioxydihydroanthracene should have a deeper colour corresponding to $1380 \times (0.65)^2 = \lambda 583$.

Dioxyanthraquinone is an exception: the two CO groups cause a new kind of vibration, and the colour is much higher—eight times as high in fact as theory predicts. No doubt the theoretical colour ($\lambda 76$) is there also, but is too low to observe.

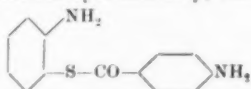
These nineteen doubly-linked dicyclic colours have been selected so as to cover the whole field, so far as known (the peroxide and sulphoxide dyes are not yet known): it would merely be taking up space, for example, to calculate erythrosine when eosine is calculated, or to calculate the fourteen derivatives of thionine observed by Formánek.

There are also dicyclic dyes in which the rings are joined by chains longer than one element: indigo and the azo-dyes are examples, but the published *data* are insufficient—indeed almost useless—as regards a quantitative explanation.

Indigo may be calculable from the hydrated formula:



and the thiazole and primuline dyes similarly, viz.:



but the laws of the co-operation of two or more factors in a linkage are not yet known. The azo-dyes do not come into the scheme for the reason that they are coloured whether they contain ionisable groups or not; but it is worth noting that the three which *do* contain two ionisable rings (azophenol, azoaniline, etc.) have colours fairly similar to those of the corresponding phenazines, from which they differ by two hydrogen atoms only. This suggests that the azo group can sometimes be written —NH—NOH— and the colour calculated accordingly, allowing about 0.73 instead of 0.78 for the <NH> factor when not replacing two hydrogen atoms of the benzene rings but inserted in a previously existing linkage.

The most of the azo-dyes, however, owe their colour to the azo-linkage independently of all rings, since diazomethane shows colour.

It is probably desirable to show the way in which the linkage-factors were ascertained from the observations, particularly as this also exhibits the degree of variation of each factor, and enables the reader to see that each factor is really a constant within the observational error.

(1) *The oxo-linkage.*—(a) Resorcin-benzene: observed $\lambda 492$. The corre-

sponding substance without the oxo-linkage is benaurine, which has λ 553. Oxo-linkage-factor from (a) = $492 \div 553 = 0.890$.

(b) Fluorescein = λ 494: corresponding substance = phenolphthalein of λ 554. Oxo-factor = $494 \div 554 = 0.892$.

(c) Eosine = λ 521, whereas tetrabromophenolphthalein has λ 584. Oxo-factor = $521 \div 584 = 0.892$.

(d) Resorcin-sulphophthalein = λ 498, compared with phenolsulphophthalein of λ 563 gives the oxo-factor = 0.885.

(e) The tetrabromo-derivatives (3-3'-5-5') of the foregoing two substances have λ 527 for the resorcin compound and 594 for the phenol compound. The oxo-factor in this case is 0.887.

(f) Pyronine has λ 542 in alcohol, and Michler's hydrol has λ 610 in the same solvent. The oxo-factor in this case is 0.889.

(g) Dioxanthhydrol has λ 479 in water, and dioxibenzhydrol λ 539. The oxo-factor for this pair is thus 0.888.

(h) Tetramethyl-rhodamine has λ 553 (same as benaurine). The corresponding substance without the oxo-linkage is "dimethylanilinphthalein," which I have not observed. It is related to malachite green just as phenolphthalein λ 554 is to benaurine λ 553, therefore its λ must be that of malachite green plus 1 = λ 620. Hence the oxo-factor for this pair is $553 \div 620 = 0.892$.

(i) Resorufine has λ 576: the substance without the oxo-linkage is indophenol of λ 650. The oxo-factor here is 0.887.

(j) Hexabromo-derivatives of fluorescein and phenolphthalein substituted in the same six places (*acfgjk* of Part XI) have $\lambda\lambda$ 535 and 602 respectively. The oxo-factor from this pair is 0.889.

(k) Isomeric hexabromo-derivatives derived from 3-6 dibromophthalic acid (*adfgjk* of Part XI) have $\lambda\lambda$ 538 and 606 respectively. This oxo-ratio is 0.888.

The average of these eleven observations gives 0.889 for the oxo-ratio, but I am of opinion that, much more weight should be given to those depending on common substances, and that consequently the true value is 0.891.

(2) *The thio-linkage.*—This could be derived from as many substances as the oxo-factor, but the substances, thiofluorescein, thiopyronine, etc., are not obtainable or capable of being made here. I have therefore calculated it from the methylene-blue and thionol classes alone:

(a) Methylene-blue and Bindschedler's green have $\lambda\lambda$ 665 and 730 respectively. The ratio is 0.912.

(b) Thionine and indamine have $\lambda\lambda$ 603 and 660 respectively. The ratio is 0.915.

(c) Thionol and indophenol have $\lambda\lambda$ 593 and 650 respectively. The ratio is 0.913.

I hope that some one will examine the thioxanthhydrol dyes, and thus enable the thio-factor also to be stated to three places of decimals.

(3) *The imino-linkage.*—The acridine dyes are NH-derivatives of the benzhydrol dyes: similarly the phenazines are related to the indophenols.

(a) Flavine (diaminoacridine) has λ about 427, whilst diaminobenzhydrol has λ 548. The NH ratio is here 0.780.

(b) Benzoflavine A (substance No. 27 without the methyl-groups) has λ about 450 (broad). The corresponding substance without the NH group is Doebner's violet, which has λ 562. The NH ratio is here 0.80. This, being exceptional, is probably wrong. The acridine dyes analogous to the phthaleins and rhodamines appear to be little known, and are inaccessible here ('Beilstein,' iv, supplement, p. 879. Calculated λ 438.)

(c) Bisdimethylamino-phenazine has λ about 565, and Bindschedler's green λ 730. The NH ratio is here 0.774.

(d) Dioxyphenazine has λ about 510 (broad), and indophenol λ 650. The NH ratio is here 0.785.

(e) Safranine (without methyl groups) has λ 525 compared with indamine λ 660, giving 0.796 for the NPh ratio, whence NH is $0.796 \div 1.026 = 0.778$.

(4) *The methylene-linkage.*—This is inferred from the acridine dyes, this time compared with the indophenols, on the principle that when two linkages are present it does not matter which is the oxidised one, *i.e.* ($\text{CH}_2 + \text{NOH}$) = ($\text{CHOH} + \text{NH}$).

(a) Flavine / indamine = $427 / 660$. Value of $\angle \text{CH}_2 \backslash = 0.647$.

(b) Dioxyacridine / indophenol = $421 / 650$. Value of $\angle \text{CH}_2 \backslash = 0.649$.

The oxidised factors.—Here the supposition is made that since a factorial scheme has been shown to be generally successful, and since Watson and Meek have established the factor $\frac{2}{3}$ for the change of linkage from CHOH to CO , this factor $\frac{2}{3}$ will also hold for any other oxidation of the linkage. Hence the value of $\angle \text{CHOH} \backslash$ is $\frac{2}{3}$ of $\angle \text{CH}_2 \backslash = 0.39$, and $\angle \text{NOH} \backslash = \frac{2}{3}$ of 0.78, and so on. That this supposition is correct is proved by the consistency of the results given in this paper.

The next step is to calculate the colour of the unobservable singly-linked dicyclic substances:

(1) *Dioxy-phenyl ether.*—This is (1) dioxyxanthhydrol less CHOH : calculated λ $479 \div 0.39 = \lambda$ 1229, (2) resorufine less NOH : calculated λ $576 \div 0.468 = \lambda$ 1230.

(2) The calculation for the sulphur-ether *dioxyphenylsulphide* gives λ 1258.

(3) *Dioxy-diphenylamine.*—This from dioxyphenazine is calculated to have λ $510 \div 0.468 = \lambda$ 1090: from dioxyacridine the calculated value is λ $421 \div 0.39 = \lambda$ 1080: from resorufin λ $576 \div (\frac{2}{3} \text{ of } 0.891) = \lambda$ 1077 and so on.

(4) *Dioxy-diphenylmethane.*—This from dioxyacridine is calculated to

have $\lambda 421 \div 0.468 = \lambda 900$: from dioxyxanthhydrol and the fluoresceins rather less: the average is $\lambda 898$.

The final triumph of the scheme comes when it is found that the wavelengths of the seven singly-linked substances are themselves related to a fundamental constant (about 1380) by means of the factors contained in themselves:

Dioxy-phenyl ether, $\lambda 1230$, divided by the $\diagup O \diagdown$ factor 0.891, gives 1382.

Dioxy-diphenylamine, $\lambda 1083$, divided by the $\diagup NH \diagdown$ factor 0.78, gives 1388.

Dioxy-diphenylmethane, $\lambda 898$, divided by the $\diagup CH_2 \diagdown$ factor 0.65, gives 1382.

Dioxy-benzhydrol, $\lambda 539$, divided by the $\diagup CHOH \diagdown$ factor 0.39, gives 1381.

Indophenol, $\lambda 650$, divided by the $\diagup NOH \diagdown$ factor 0.47, gives 1383.

Dioxy-phenylsulphide, $\lambda 1258$, divided by the $\diagup S \diagdown$ factor 0.92, gives 1370.

Dioxy-benzophenone, λ about 323, divided by the $\diagup CO \diagdown$ factor 0.234, gives 1380.

This makes it almost certain that the unobserved ones have really the absorption-bands in the infra-red calculated in this paper.

CRYSTALLINE STRUCTURE OF ANTIMONY AND BISMUTH.

By A. Ogg.

(With two Text-figures.)

ANTIMONY.

Antimony crystallises in the dihexagonal alternating (calcite) class of hexagonal crystals. The crystalline symmetry is that of a rhombohedron, the three edges which meet in the trigonal axis being the axes of the crystal. The angle between any two of these edges is $86^{\circ}58'$. From the geometry of the rhomb it is easy to find that the angle between the planes (111) and (110) is $37^{\circ}23'$ and that between the planes (100) and (111) is $56^{\circ}48'$.

If we take the sides of the rhomb to be a and suppose that an atom is placed at each of the corners of the rhomb, then the distances between the planes of atoms are—

$$d_{100} = .9973a \quad (1)$$

$$d_{111} = .6071a \quad (2)$$

$$d_{110} = .7236a \quad (3)$$

$$d_{\bar{1}\bar{1}0} = .6881a \quad (4)$$

By means of an X-ray spectrometer, the bulb having a palladium anticathode, the glancing angles of the first order spectra were experimentally found to be—

(100)	(111)	(110)
$5^{\circ}30'$	$4^{\circ}30'$	$7^{\circ}30'$

Applying the formula $n\lambda = 2d \sin \theta$, where n is the order of the spectrum, $\lambda = 0.584 \times 10^{-8}$ cm., and θ the observed glancing angle, we find—

$$d_{111} = 3.72 \times 10^{-8} \text{ cm.} \quad (5)$$

$$d_{100} = 3.05 \times 10^{-8} \text{ " } \quad (6)$$

$$d_{110} = 2.24 \times 10^{-8} \text{ " } \quad (7)$$

From (2) and (5) we find $a = 6.12 \times 10^{-8}$ cm.

" (1) " (6) " " $a = 3.06 \times 10^{-8}$ "

" (3) " (7) " " $a = 3.09 \times 10^{-8}$ "

It is evident from the calculated values of a that the spacings between the (100) planes and also those between the (110) planes are half what we

have supposed them to be by placing atoms merely at the corners of the rhomb. If we take a face-centred lattice—

$$\text{then } d_{111} = \cdot 6071a \text{ as before (8)}$$

$$\text{but } d_{100} = \cdot 499a \quad (9)$$

$$\text{and } d_{110} = \cdot 367a \quad (10)$$

$$\text{hence from (5) and (8) } a = 6 \cdot 12 \times 10^{-8} \text{ cm.}$$

$$(6) \quad \text{,,} \quad (9) \quad a = 6 \cdot 18 \times 10^{-8} \quad \text{,,}$$

$$(7) \quad \text{,,} \quad (10) \quad a = 6 \cdot 12 \times 10^{-8} \quad \text{,,}$$

$$\text{mean value of } a = 6 \cdot 14 \times 10^{-8} \quad \text{,,}$$

Taking the density of antimony as 6.70 grms./cm.³ the mass of the rhomb is equal to—

$$\begin{aligned} & 6 \cdot 70 \times 6 \cdot 14^3 \times 0 \cdot 9973^2 \times 10^{-24} \\ & = 1545 \times 10^{-24} \text{ gm.} \end{aligned}$$

Since the atomic weight of antimony = 120.2, and the mass of the hydrogen atom = $1 \cdot 64 \times 10^{-24}$ gm., then $n \times 120 \cdot 2 \times 1 \cdot 64 \times 10^{-24} = 1545 \times 10^{-24}$ gm., where n is the number of atoms per unit rhomb. This gives $n = 7 \cdot 85$.

It is clear, then, that there are 8 atoms per unit rhomb.

Let us take 8 atoms per unit rhomb, find the mass of the rhomb, hence its volume and then find a . We find $a = 6 \cdot 20 \times 10^{-8}$ cm.

Assuming a face-centred lattice we find then—

$$d_{100} = 3 \cdot 09 \times 10^{-8} \text{ cm.}$$

$$d_{111} = 3 \cdot 76 \times 10^{-8} \quad \text{,,}$$

$$d_{110} = 2 \cdot 24 \times 10^{-8} \quad \text{,,}$$

$$d_{110} = 2 \cdot 13 \times 10^{-8} \quad \text{,,}$$

We can now calculate the glancing angles for the spectra from the different faces.

	Planes.		
	(100)	(111)	(110)
Observed angle	5° 30'	4° 30'	7° 30'
Calculated	5° 25'	4° 27'	7° 32'

Arrangement and Spacings of the Atoms.

(a) (111) planes:

We conclude that the underlying structure is the face-centred lattice, but a face-centred lattice gives only 4 atoms per unit rhomb. To determine the positions of the other 4 atoms we must investigate the relative intensities of the spectra from different faces. The observed intensities of the spectra of five orders from the (111) planes were—30 : 100 : 33 : 4 : 12.

The first order being weaker than the second shows that there is a plane of atoms dividing the distance ($3 \cdot 76 \times 10^{-8}$ cm.) between the (111) planes. Let β be the phase difference between the two sets of planes, and taking the

intensities^{*} of a normal set of spectra to be 100 : 34 : 14 : 7 : 4, we have

$$\frac{30}{100} = \frac{100}{34} \frac{1 + \cos\beta}{1 + \cos 2\beta'}$$

which gives $\beta = 148^\circ$ approximately.

The distance between one set of (111) planes would be divided by another set of (111) planes in the ratio of 0.412 : 0.588.

The calculated ratios of the intensities for this spacing are 30 : 100 : 31 : 5 : 15, which is in close agreement with the observed ratios.

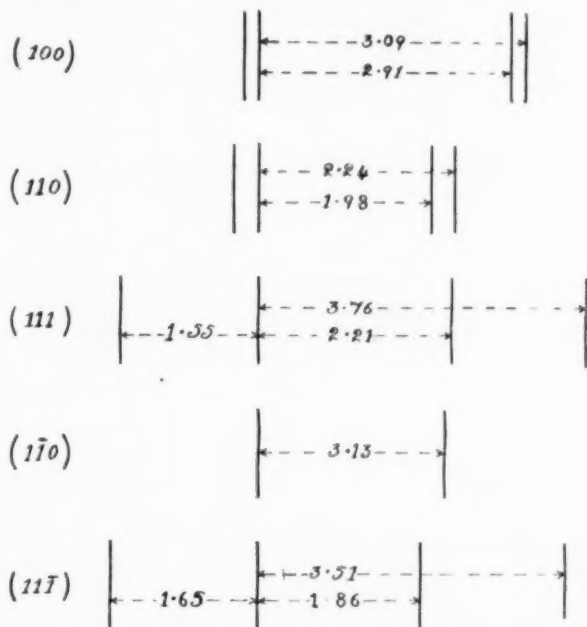


FIG. 1.—Spacings of planes in Angström units (10^{-8} cm.).

The spectra could be explained by a structure similar to that of the diamond but distorted along the trigonal axis,† one set of (111) planes dividing the distance between those belonging to the other in the ratio of about 3 : 2 instead of 3 : 1 as in the diamond.

(b) (100) planes :

To settle whether a structure similar to that of the diamond will fit the observed facts we must examine what this ratio would give for the spectra

* James and Tunstall, 'Phil. Mag.', S. 6, vol. 40, No. 236.

† Sir W. H. Bragg and Prof. W. L. Bragg arrived at this conclusion in 1914: 'X ray and Crystal Structure,' p. 227.

from the (100) planes. We find at once that it will not explain the (100) spectra.

The observed (100) spectra are nearly normal, and there can be only a small difference of phase between the two sets of planes. James and Tunstall* have shown that this can be accomplished in the following way. Divide the unit face-centred rhomb into eight equal rhombohedral cells. Place an atom at each of the unoccupied corners of the small cells and then

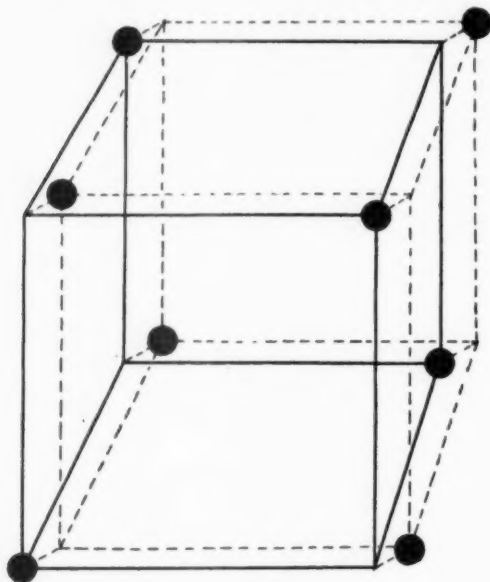


FIG. 2.

push each atom along the diagonal by an amount equal to 0.074 of the length of a diagonal of one of the small cells.

The spacings we have determined for the (111) planes would make this amount to be 0.059 instead of 0.074.

The spacing for the (100) planes would be 0.059 : 0.941. The two sets of planes differ in phase by about 21° , and would give a nearly normal set of spectra in agreement with observation.

(c) (110) planes :

We must now examine whether such an arrangement would suit the spectra from the (110) planes. The planes would contain an equal number of atoms, and the spacings are 0.118 : 0.862.

* James and Tunstall, *loc. cit.*

The intensities of the first three orders were observed to be 100 : 17 : 0, while calculation gives 100 : 20 : 3.

(d) (110) and (111) planes :

James and Tunstall examined the spectra from these planes and found that they agreed with this arrangement.

The spacings of the planes have been determined by the relative intensities of the spectra from the (111) planes ; hence the determinations of these intensities are of importance. The ratios were found to be 30 : 100 : 33 : 4 : 12, while James and Tunstall found 60 : 100 : 48 : 0 : 15, giving a phase difference of 140° between the two sets of planes. We found a phase difference of 148° .

The spacings of the planes are given in Fig. 1. Fig. 2 shows the arrangement of the atoms on one of the eight small cells into which the rhombohedron can be divided.

The shortest distance between atomic centres is 2.92×10^{-8} cm.

BISMUTH.

Bismuth, like antimony, crystallises in the dihexagonal alternating system (calcite class). The three edges of the rhombohedron meet in the trigonal axis and the angle between any two of the edges is $87^\circ 34'$. The angle between the faces (100) and (111) is $56^\circ 24'$.

Again using an X-ray bulb with a palladium anticathode the glancing angles for the first order spectra were—

(111)	(100)
$4^\circ 18'$	$5^\circ 8'$

Taking the density of bismuth 9.80 gm./cm.³ we find that the unit rhomb contains 8 atoms and that the length of the side of unit rhomb is 6.52×10^{-8} cm.

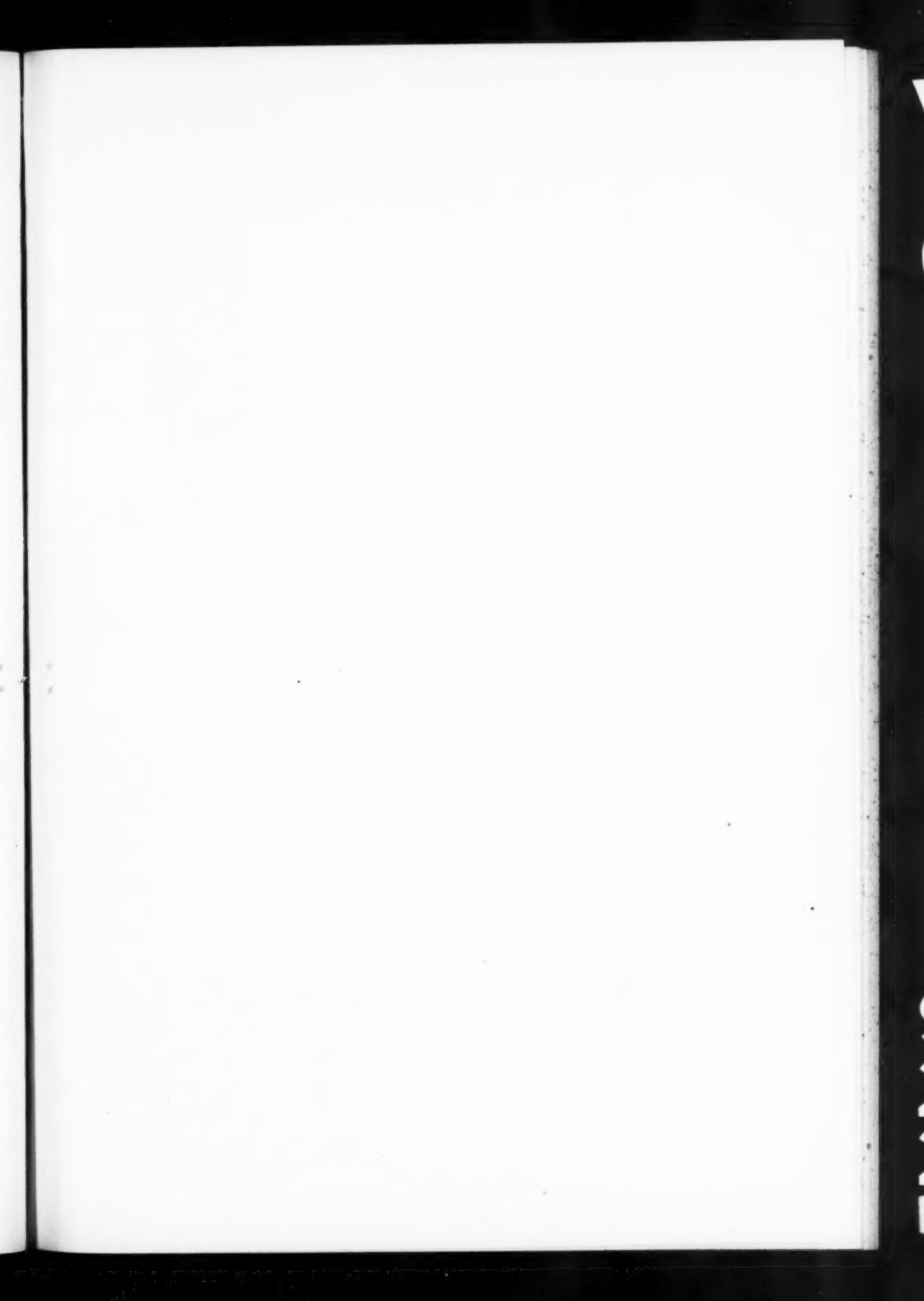
Assuming the structure of crystalline bismuth to be similar to that of antimony we find the spacings of one set of planes to be—

Planes.				
(100)	(110)	(111)	($\bar{1}\bar{1}0$)	(111)
Spacings 3.25	2.35	3.92	2.25	3.69

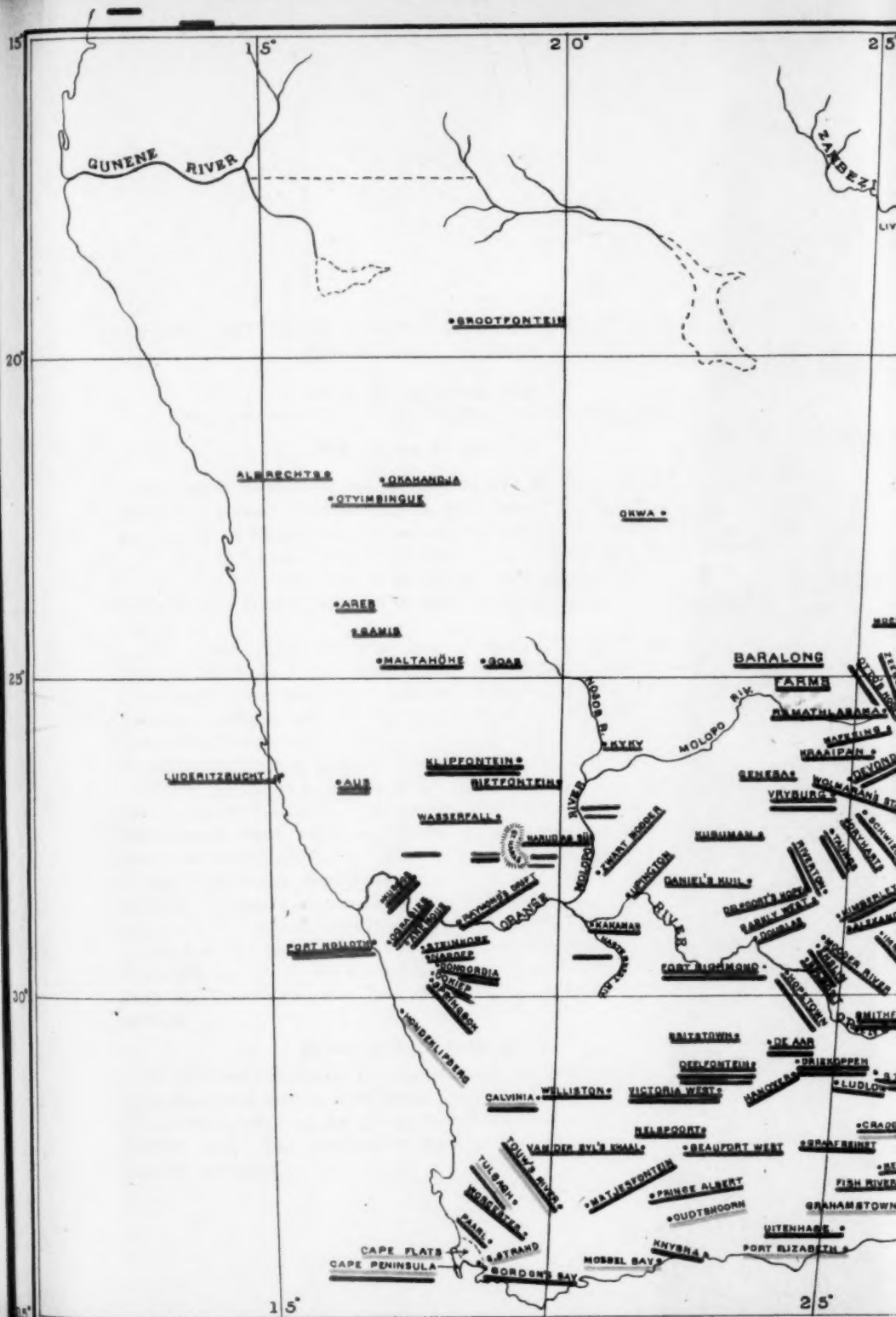
The spacings are given in Ångström units (10^{-8} cm.) The relative positions of the two sets of planes have not been accurately determined. The intensities of the spectra from the (111) face showed much the same order as those from the corresponding face of antimony but were much fainter.

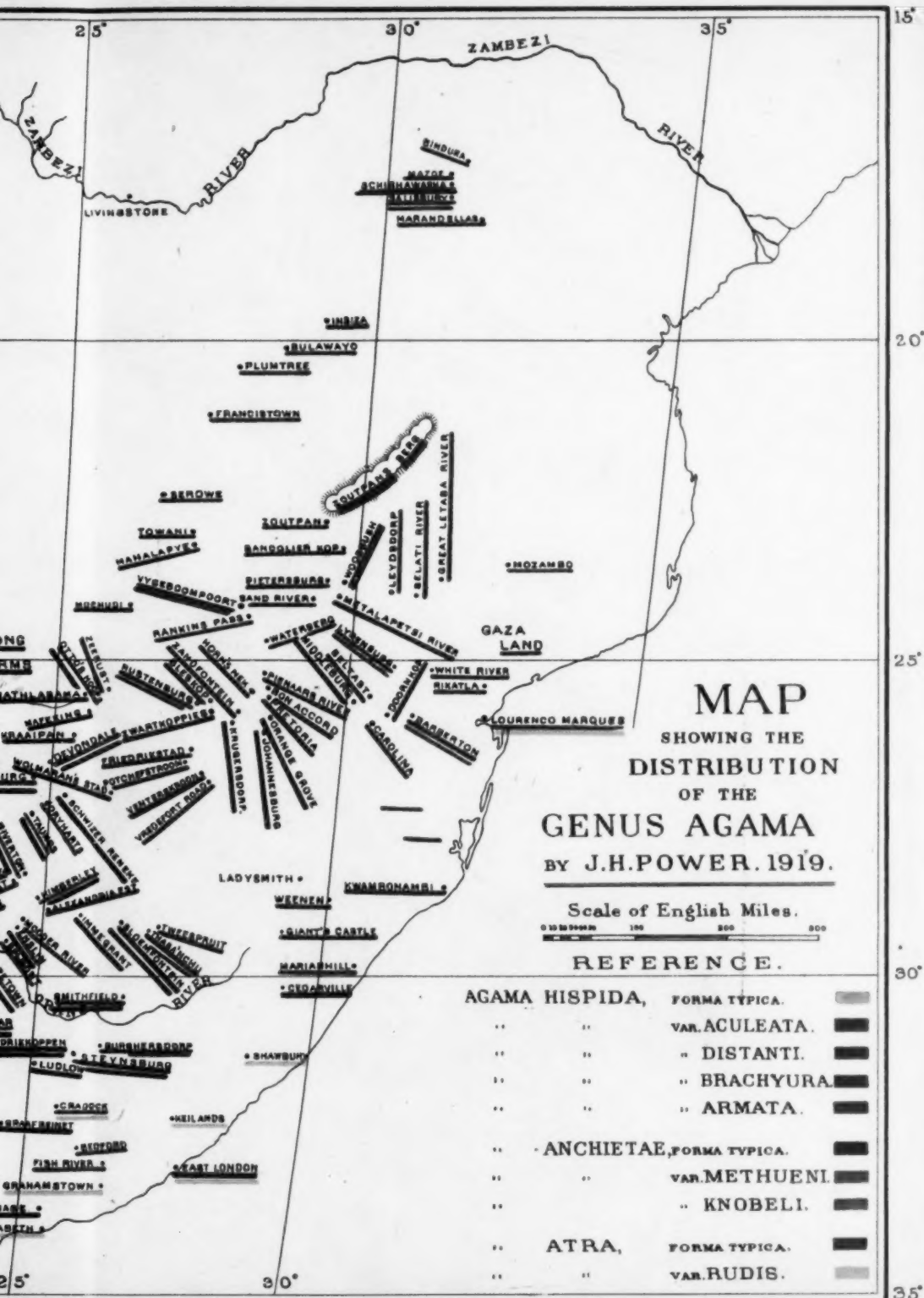
Experiments are in progress for the measurement of these intensities whereby the second set of planes may be fixed.

UNIVERSITY OF CAPE TOWN,
February, 1921.



G. A. BOULENGER and J. H. POWER.—Map showing the distribution of the genus *Agama*. (Left over from the paper on the subject published in Vol. IX, Part 3.)





ON THE REPTILIAN GENERA *EUPARKERIA* BROOM, AND
MESOSUCHUS WATSON.

By S. H. HAUGHTON, B.A.

(Published by permission of the Rt. Hon. the Minister for Mines and Industries.)

(With Plates II and III.)

The genus *Euparkeria* was founded by Dr. Broom in 1913 for the reception of a small Thecodont reptile from Aliwal North. The type of the genus is an almost complete skeleton including a beautiful skull and lower jaw. In his description of the form Broom differentiated *Euparkeria* from a genus *Mesosuchus*, the two having been grouped previously under the latter name by Watson, who was unaware of the existence of the skull of *Euparkeria*.

The recent acquisition of the famous "Alfred Brown" Collection of fossils by the South African Museum has enabled more development work to be done on the masses of sandstone containing the *Euparkeria* and *Mesosuchus* remains, and the consequent discovery of more skulls and partial skeletons which throw a little more light upon the structure of these two different forms has resulted.

The remains occur in a mass of greenish-grey sandstone which in the main is highly calcareous. The matrix, however, is comparatively easily freed from the bones, which are left clean, and the various sutures of the skulls are clearly displayed. Most of the material recently uncovered belongs to the genus *Euparkeria*, but a fairly complete new skeleton undoubtedly belongs to the interesting Acrodont form *Mesosuchus*. The discovery of a skull of *Euparkeria* lying in close proximity to the pelvis described by Broom as *Browniella africana* has led to the re-examination of the bones of *Browniella*, and the conclusion has been reached that the pelvis and shoulder-girdle said to belong to that form are in reality specimens of *Euparkeria capensis*.

EUPARKERIA CAPENSIS BROOM.

In addition to a number of isolated bones the following are the chief specimens of this species, all of which come from a locality known as the Krietfontein Spruit on the Aliwal North Commonage, and are of Upper Beaufort age. (The numbers in brackets refer to the South African Museum catalogue.)

Specimen 1 (5867).—The type. Consists of skull, lower jaw, shoulder-girdle, cervical and dorsal vertebrae, right fore-limb without hand, abdominal ribs, pelvis, and most of the left hind limb. Associated with this by Broom is another dentary, and a complete pes.

Specimen 2 (6047).—A complete skull and lower jaw, humerus, pelvis and shoulder-girdle (described previously as *Browniella africana*), femur in articulation with pelvis, vertebrae, ribs, abdominal ribs.

Specimen 3 (6048).—Skull, of which the bones are disarticulated and scattered but not broken, pelvis, of which the ilium was figured by Broom ('Proc. Zool. Soc.,' 1913, pl. lxxviii, fig. 18), hind limb, some vertebrae and ribs.

Specimen 4.—Dorsal vertebrae, pelvis (ilium figured by Broom, 'Proc. Zool. Soc.,' 1913, pl. lxxviii, fig. 17), hind limb, coracoids and interclavicle.

Specimen 5.—Disarticulated skull, scapula, fore limb, hind limb, and some vertebrae.

Specimen 6.—A portion of the antorbital part of the skull and lower jaw showing a little of the palate.

Skull.—Specimen No. 2 contains an almost complete skull and lower jaw, of which some of the bones are slightly displaced. Pressure has cleaved the skull along the middle line except at the snout, and has crushed the left side so that the left frontal is vertical and the left nasal is horizontal, but at a lower level than its neighbour. The left ramus of the mandible is in its correct position but the right ramus has been displaced. All the sutures are beautifully shown, but accurate measurements are not possible, save those of each separate bone.

The skull is undoubtedly of the same species as the type and almost of the same size; but it displays one or two features which are not shown by the type-specimen.

The front part of the left premaxilla is as conjectured by Broom, being a slender pillar of bone bounding the front of the large nostril and meeting the nasal above it. The postnasal portion of the bone is seen to overlap the descending part of the nasal on the outside, and the suture between the two is somewhat different from that in Broom's figure. The premaxillary teeth are not seen.

The nasal-maxillary articulation is longer than in the type; the frontoparietal and fronto-postfrontal sutures are jagged; the maxilla and jugal are supplied with a number of small foramina, mostly passing forwards into the bones; and the distal end of the quadrate is broader than in the figures given. Apart from these facts nothing can be added to Broom's description, with which this skull closely agrees. No sclerotic plates, however, are preserved.

The lower jaw shows several features which are not displayed by the type. The dentary forms the anterior half of the ramus and forms the

symphysis, articulating posteriorly with the surangular and angular. The lower view of the ramus shows a splenial lying within the dentary forming part of the lower border of the jaw, passing back almost to the level of the front of the external mandibular foramen but not reaching the symphysis anteriorly. Lying wedged between the lower half of the dentary and the posterior half of the splenial is the anterior prolongation of the angular. The angular forms the lower border of the external mandibular foramen, and the lower border of most of the hinder half of the ramus. The surangular lies dorsal to the angular, and extends from the dentary to the articular. Just anterior to the articular it has a fairly large nutritive foramen; above the external mandibular foramen and just below the dorsal edge of the bone is a well-defined groove leading backwards to a small foramen; and the upper edge of the bone is thickened to form a small flange. Lying below the posterior half of the surangular and apparently passing between it and the angular is a slight splint-bone which I take to be a prearticular. It is small. The limits of the articular are not well defined. At the actual articular surface it is bounded outwardly by the surangular, which passes back to lie outside the postarticular process. The articular surface is shallowly concave and broad for the reception of the broadened quadrate. I can see no evidence of a coronoid.

The teeth, at least in the lower jaw, are serrated on their anterior and posterior borders, the posterior serrations being much the coarser of the two sets. I can see no definite trace of anterior serrations in the upper jaw, and some teeth are certainly without.

Specimen No. 6 is of interest as showing a small fragment of the palate in association with part of the side of a skull. The specimen is somewhat unsatisfactory, but it is possible to identify the elements present. Most of the left orbital and preorbital region is preserved, and the front of the left ramus of the lower jaw; the stone containing the specimen has split almost longitudinally, so that the inner face of the maxilla is seen on one piece and the outer side of the jugal on the counterpiece. Comparison of the lower jaw with the type shows that the specimen is not quite full grown. The lower jaw shows definitely that the splenial plays no part in the symphysis. The only real point of interest in the specimen is the evidence of small teeth on the palate. These are short, blunt, smallish teeth exposed in a row of four or five on a bone, which apparently articulates latero-anteriorly with the hinder part of the maxilla. The teeth begin behind the level of the orbit and are placed in the long axis of the skull. It is probable that they are borne by the pterygoid, as in the somewhat earlier form *Proterosuchus fergusi*.

It should be noted that there is in the collection another fragment showing a portion of the maxilla with two thecodont teeth, serrated posteriorly; and associated with it a bone of the palate carrying a row of eight

short pointed slightly backwardly-curved small teeth, apparently unserrate. It seems indisputable, therefore, that *Euparkeria* had palatal teeth and was thus more primitive than *Ornithosuchus*—a conclusion strengthened by the discovery of the prearticular in the lower jaw of the South African form.

Humerus.—The humerus of the type is only displayed in its outer aspect; but a complete left humerus has been isolated from skeleton No. 2. The greatest length of the bone is 45 mm., its maximum proximal width 20 mm., and its distal width 16 mm. The shaft is very slender, but the bone expands considerably at the ends, especially proximally. The lower end of the deltoid crest is only 14 mm. from the proximal edge of the bone, and the crest thus lies high up as in *Ornithosuchus*. The inner face of the proximal end is mostly flat, but is slightly concave laterally. The distal condyles are separated by a basin-like depression. There is no entepicondylar foramen.

Ilium.—The specimen from which Broom figured the imperfect ilium (1913, fig. 18) also contains a perfect right ilium which has been fully developed. The whole bone is 20 mm. high and the iliac crest 28 mm. long. The acetabulum is large and closed and there is a very pronounced supra-acetabular crest. The height of the acetabular portion of the bone is 13 mm. The anterior spine of the crest is short and bluntly rounded, the posterior spine long. The acetabular crest is continued on to the pre-acetabular process, but not to the post-acetabular process. The lateral face of the upper portion of the bone is strongly supplied with ridges running at right angles to the upper border, especially in the anterior portion.

Femur.—Directly associated with the pelvis figured by Broom as that of *Browniella africana* I have discovered a left femur. The head of the bone lies just under the ischium and the bone is at right angles to the plane of the ischium. It is closely similar to that of *Euparkeria capensis*, having a length of 59 mm., the femur of *Browniella* being 74 mm. long; and this coupled with the fact that a skull and lower jaw of *Euparkeria* was found in the sand-stone lying directly under the same pelvis opens up the question of the identity of the pelvis figured by Broom.

Broom has referred to the differences which exist between this pelvis and that of the type of *Euparkeria*. "The ischium differs in shape in being constricted near its middle, and the pubis, besides being much broader and stouter, differs in having only a single pubic foramen." Further development and a careful examination of the "*Browniella*" pelvis seem to show that these differences were rather too strongly accentuated. Ilium, pubis and ischium are certainly larger than those of the other specimens, of *Euparkeria* examined; but their relative sizes are apparently the same. The constriction of the ischial plate does not exist—the appearance of constriction is due to a broken edge of the bone, the true shape being evident on the matrix beneath. The ilium is of exactly the same type as in

Euparkeria. There is some doubt as to the value of the other point of difference mentioned. None of the pubes of *Euparkeria* are quite entire, but in at least one there is no evidence of a second pubic foramen.

In view, therefore, of the general similarity of the pelvis to that of *Euparkeria*, its articulation with a typical *Euparkeria* femur and its close association with an undoubted *Euparkeria* skull and lower jaw, it must be concluded that this pelvis is a large girdle of *Euparkeria capensis*, its difference in size from the type being probably due to differences of sex. It is worthy of note that Watson found similar differences in two skeletons of *Procolophon*, of which he writes—"The male and female skeletons are of exactly the same length, as are their skulls. The dentition is quite similar in the two specimens, and I think there is not the slightest doubt that they belong to the same species. The female skeleton is, however, much more lightly built, having narrower and more slender limb-girdles, and limbs which are less than three-quarters as long as those of the male skeleton and much less robust. Mr. Boulenger tells me that differences of this kind often distinguish the sexes in living lizards, and I think it is extremely probable that the same reason accounts for the difference between my two skeletons." In *Euparkeria* the limb bones are more closely similar in the two sexes than in *Procolophon*, but there is a marked difference in the size and strength of the pelvis and shoulder-girdle.

BROWNIELLA AFRICANA Br.

In view of the foregoing discussion, I take as the type of *Browniella* an isolated femur, longer than that of *Euparkeria* and somewhat less curved. The resemblances between the two are great, but from the figures it will be seen that in *Browniella* the trochanter is considerably straighter. The distal end is less broadened than in *Euparkeria*.

MESOSUCHUS BROWNI Watson.

The fortunate discovery of a second specimen of this interesting form in the Brown collection enables certain new facts to be added to our knowledge of it. The specimen consists of a fairly complete articulated skeleton lacking the skull—of which only a portion of a maxilla is preserved—of which the pelvis, hind limb and fore limb have been developed. The type of the genus is a somewhat unsatisfactory specimen; but this second piece agrees very closely with the type in size and specific characters. It is unfortunate that the skull is not preserved.

The fragment of maxilla is about 30 mm. long and carries nine blunt round acrodon teeth, which are not arranged in a single row but somewhat irregularly.

Of the fore limb the parts preserved are the distal end of the humerus,

the radius and ulna and the hand. The distal end of the humerus is 17 mm. broad. It has two distinct condyles with a broad shallow depression between them. There are no epicondylar foramina.

The radius has a length of 33 mm., and consists of a thin shaft expanding at each end to a width of about 7 mm. The distal end is cup-shaped for the reception of the radiale, which is closely applied to the bone.

The ulna is not fully exposed. Its length may have been slightly less than that of the radius. The bones of the forearm are crossed, so that the distal end of the ulna lies on the opposite side of the radius to the proximal end.

The bony carpus consists of six elements—two fairly large proximal ones and four smaller distal ones. The largest bone articulates closely with the radius and is irregularly quadrangular in section. The other proximal element lies at the distal lateral corner of the radiale, well separated from the ulna. Its lateral face is excavate as if for the reception of another, possibly cartilaginous, element. Of the distal elements the second is small, the first and third are equal to one another in size, and the fourth slightly larger. The first, second and third articulate with metacarpals I, II and III; the fourth with metacarpal IV and partly with metacarpal V, which also articulates apparently with the outer proximal element. The metacarpals have the following lengths: I, 5 mm.; II, 10 mm.; III, 12 mm.; IV, 13.5 mm.; V, 6 mm. The digital formula is 2, 3, 4, 5, 3 (the claw of the fifth finger is displaced), and the fingers (excluding the metacarpals) have the following lengths: 1, 10 mm.; 2, 13 mm.; 3, 16 mm.; 4, 18 mm.; 5, 8 mm. The claws are comparatively long and pointed. All the fingers are slender. The fore foot is smaller than the hind foot.

The whole pelvis is preserved, practically undistorted. The left ilium is entire. As Broom has pointed out, it differs considerably from that of *Euparkeria* and resembles much more closely that of *Howesia*. The maximum vertical height of the bone is 28 mm., the height above the supra-acetabular ridge 16 mm. The length of the dorsal edge is 25 mm. The posterior extension of the crest is much less than in *Euparkeria*. The acetabulum is closed.

The ischium is a plate-like bone meeting its neighbour in a nearly complete symphysis, and sloping downwards and inwards from the acetabulum to form a very obtuse-angled depression. It is considerably shorter than that of *Euparkeria*. Its greatest length cannot have been more than 27 mm., its anterior width 13 mm. The pubis is 21 mm. broad posteriorly. It is plate-like, with the anterior half of the plate bent nearly at right angles to the posterior half, so that the two pubes together form a nearly vertical wall of bone. The anterior edges are considerably thickened laterally. The posterior edges of the bone are not quite straight, so that the articulation with the ischia was not complete, a lozenge-shaped area being left

uncovered by bone in the centre of the pelvic basin. The pubis has one pubic foramen. The bending of the bone is greater than in *Howesia* and equal to that of *Euparkeria*.

The femur is a short stout bone 50 mm. long, very different from that of *Euparkeria*. It is bent in a slight double curve. The head must have been cartilaginous, as the proximal end of the bone is excavate and finely rugose, approximating in shape to that of *Howesia*. There was a strong high trochanter at the proximal fifth of the bone. The bone differs from the femur of *Howesia* in being less expanded at the distal end and in having a stronger curve.

The tibia is 49 mm. long, the fibula 45 mm. The proximal surface of the tibia has a maximum width of 12 mm., the shaft being 5 mm. thick. The fibula is a much more slender bone with a somewhat expanded distal end.

The tarsus of the right side is seen from the plantar side, and is slightly displaced. In the proximal series there are three bones. A large bone, obviously formed by the fusion of two, lies directly opposite the distal ends of the lower bones of the leg. It is 14 mm. at its widest and has a maximum length of 7 mm. Lateral to it and apparently lying partly above it is a bone which has only a small triangular plantar face. External to this and partly articulating with the first is another large bone whose inner edge is raised and whose under-surface is saddle-shaped. The dimensions of this bone are 11 mm. by 8 mm. In the distal row four tarsalia are seen, of which the fourth is the largest. The metatarsals are not fully displayed, with the exception of the first and fifth. The first is a short stout bone; the fifth is remarkably similar to that of *Howesia*. The digital formula is not obtainable.

There can be little doubt that in the structure of the girdles and limbs *Mesosuchus* and *Howesia* are closely allied forms. The pelvis is very similar in the two genera and so is the general form of the limb-bones, while the similarity in the fifth metatarsal is very striking. The manus is not known in *Howesia*, and its interpretation in *Mesosuchus* is not beyond doubt. Much of the carpus was undoubtedly cartilaginous. There were certainly four distal carpalia. I have interpreted the other two bones as radiale and ulnare; the absence of a bony intermedium is strange, but there is room for it between the two proximal bones of the carpus. There were almost certainly cartilaginous centralia, and the lateral surface of the supposed ulnare is excavate as if for articulation with a cartilaginous pisiforme. The digital formula of the hand is primitive.

The structure of the tarsus is fairly clear, although the whole foot has been turned at an angle to the leg. The large bone which articulates with the tibia and fibula is taken to be a fused centrale and tibiale; lateral to this and just possibly fused with it (although a suture seems undoubted on the

plantar side) is the intermedium. Lateral to this is the large fibiale with a pronounced heel. This structure differs from that of *Howesia* in the fusion of the tibiale and centrale. Such a fusion is paralleled in stage Q of *Sphenodon*; and a further fusion with the intermedium is seen in *Procolophon*. In the rest of the foot *Howesia* and *Mesosuchus* agree. A specimen from Burghersdorp (S.A. Mus. Cat. No. 5861) collected by Dr. du Toit shows the fingers and toes of a species of either *Howesia* or *Mesosuchus*. The fifth metatarsal is of exactly the same type as in those genera, and the digital formula of the pes is 2, 3, 4, 5, 3. The third metatarsal is the longest.

The femur in the Howesiidae differs from that of the Pseudosuchia such as *Euparkeria* and approximates more closely to that of *Erythrosuchus*, but in the latter the large medial trochanter is not terminal. The forms agree with *Erythrosuchus*, too, in the sudden bending down of the anterior portion of the pubis; but the ilium lacks the posterior prolongation seen in both *Erythrosuchus* and *Euparkeria*.

EXPLANATION OF PLATES II AND III.

FIG.

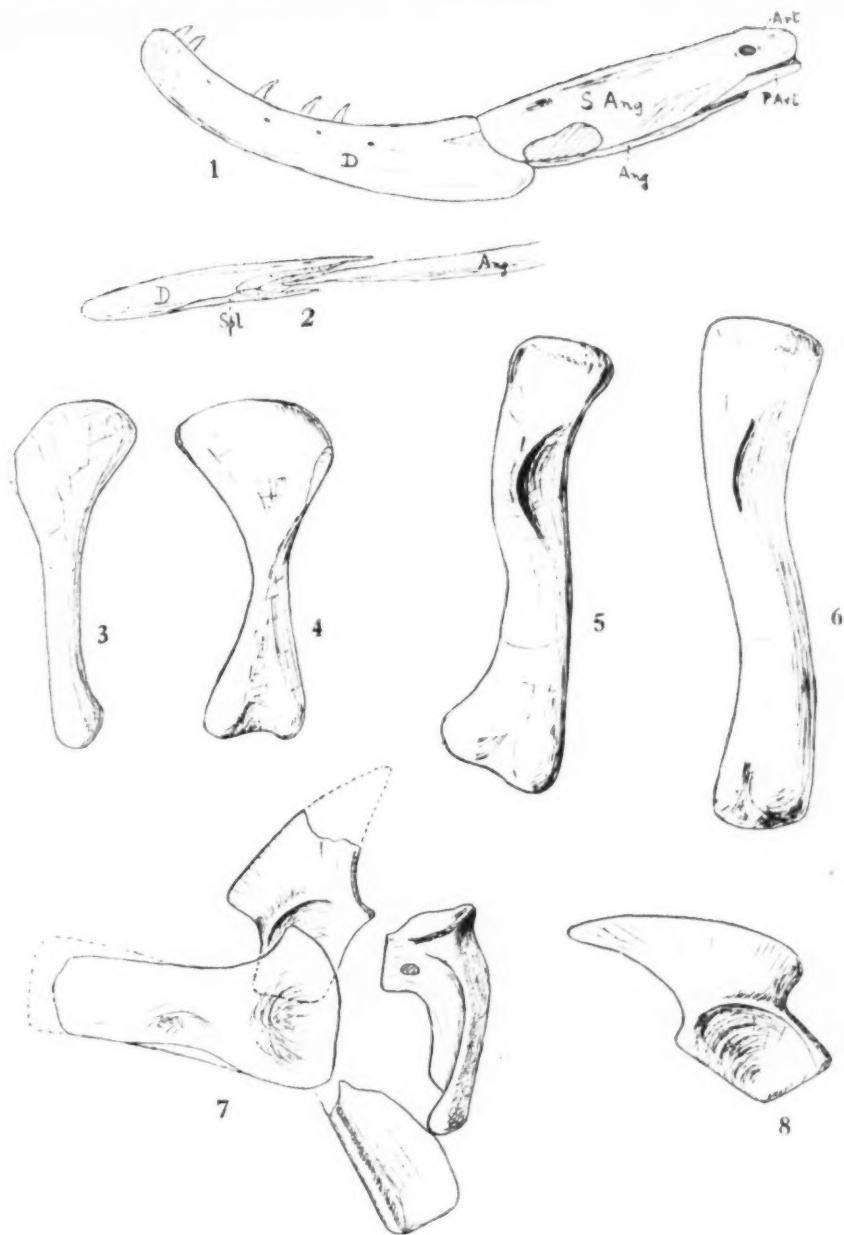
PLATE II.

1. *Euparkeria capensis*. Outer view of left dentary of Specimen No. 2.
2. *Euparkeria capensis*. Lower view of same.
3. *Euparkeria capensis*. Lateral view of humerus of Specimen No. 2.
4. *Euparkeria capensis*. Medio-anterior view of same.
5. *Euparkeria capensis*. Femur.
6. *Browniella africana*. Femur.
7. *Euparkeria capensis*. Pelvis of Specimen No. 2.
8. *Euparkeria capensis*. Right ilium of Specimen No. 3.

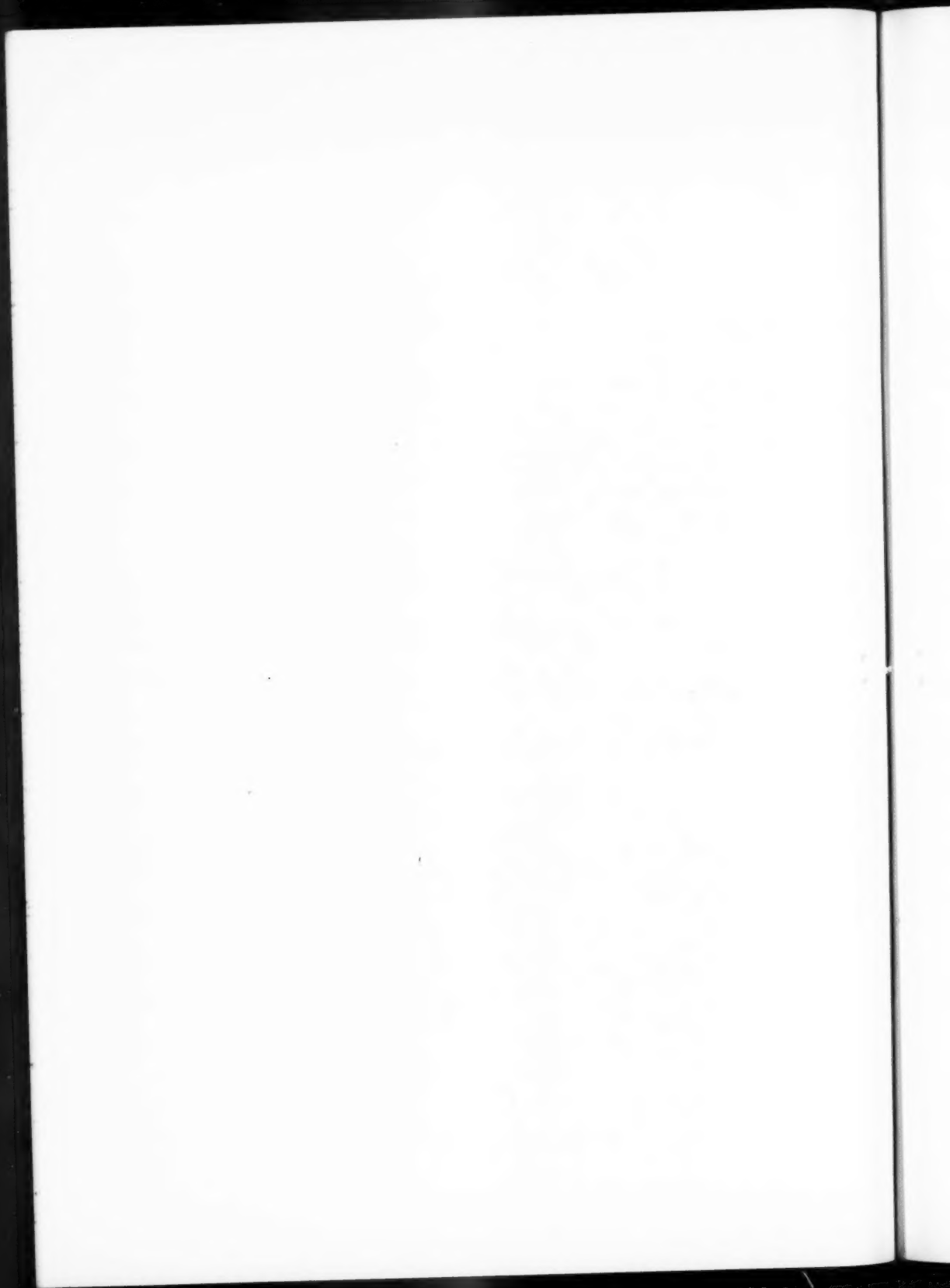
PLATE III.

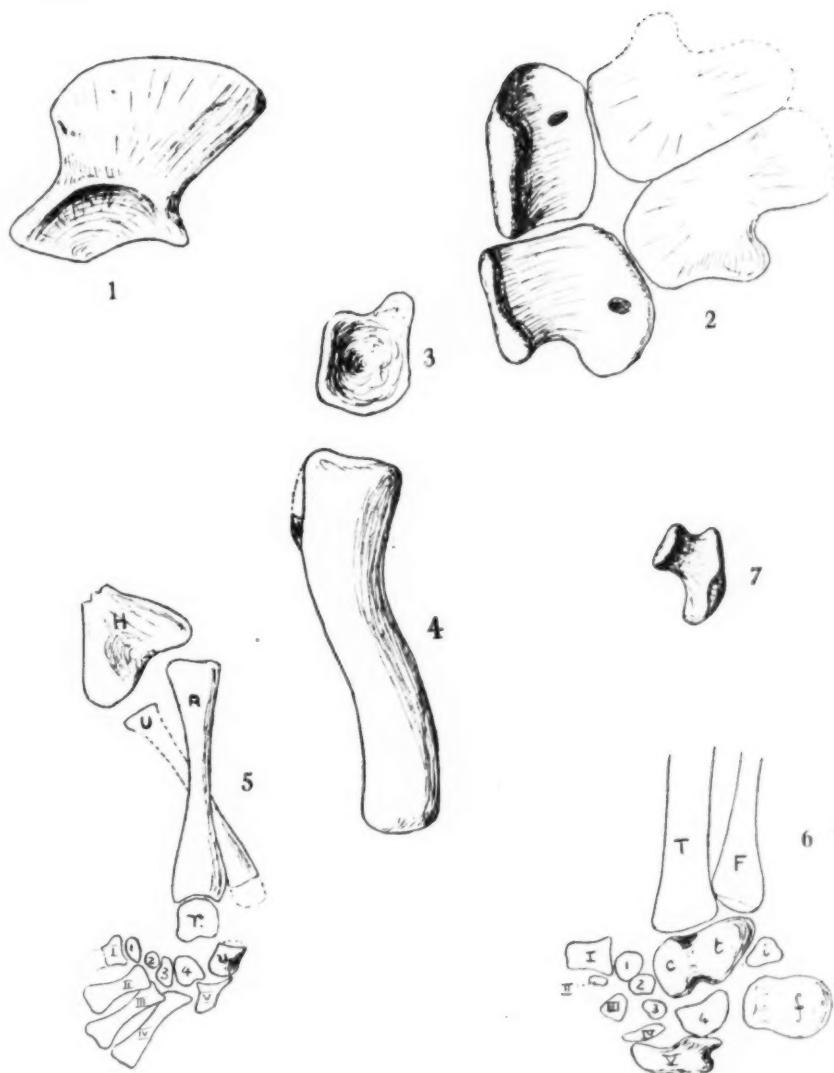
Mesosuchus browni, Watson.

1. Left ilium.
2. Pelvis from below.
3. Proximal end of femur.
4. Femur.
5. Fore limb, showing carpus.
6. Hind limb, showing tarsus.
7. True view of metatarsal V.



Euparkeria, Broom, and *Brouniella*, Broom.





Mesosuchus browni, Watson.

NOTE ON THE PRODUCT OF ANY DETERMINANT AND ITS BORDERED DERIVATIVE.

BY SIR THOMAS MUIR, LL.D.

(1) The fundamental result here obtained is the theorem that *the product of two determinants, the second of which is got by bordering the first, is expressible as a bilinear function of which the quasi variables are the cofactors of the bordering elements in the second determinant, and the discriminant is the unbordered determinant.* For example, when the order of the initial determinant is the 3rd we have

$$-\begin{vmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{vmatrix} \cdot \begin{vmatrix} a_1 & a_2 & a_3 & a_4 \\ b_1 & b_2 & b_3 & b_4 \\ c_1 & c_2 & c_3 & c_4 \\ d_1 & d_2 & d_3 & . \end{vmatrix} = \begin{matrix} D_1 & D_2 & D_3 \\ a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{matrix} \begin{matrix} A_4 \\ B_4 \\ C_4 \end{matrix}.$$

By way of proof we note that on the right-hand side the cofactor of A_4

$$\begin{aligned} &= a_1 D_1 + a_2 D_2 + a_3 D_3 \\ &= -a_1 \begin{vmatrix} a_2 & a_3 & a_4 \\ b_2 & b_3 & b_4 \\ c_2 & c_3 & c_4 \end{vmatrix} + a_2 \begin{vmatrix} a_1 & a_3 & a_4 \\ b_1 & b_3 & b_4 \\ c_1 & c_3 & c_4 \end{vmatrix} - a_3 \begin{vmatrix} a_1 & a_2 & a_4 \\ b_1 & b_2 & b_4 \\ c_1 & c_2 & c_4 \end{vmatrix} \\ &= -\begin{vmatrix} a_1 & a_2 & a_3 & . \\ a_1 & a_2 & a_3 & a_4 \\ b_1 & b_2 & b_3 & b_4 \\ c_1 & c_2 & c_3 & c_4 \end{vmatrix} = -\begin{vmatrix} a_1 & a_2 & a_3 & . \\ . & . & . & a_4 \\ b_1 & b_2 & b_3 & b_4 \\ c_1 & c_2 & c_3 & c_4 \end{vmatrix} \\ &= -a_4 \begin{vmatrix} a_1 & b_2 & c_3 \end{vmatrix}, \\ &= \text{cofactor of } A_4 \text{ on the left;} \end{aligned}$$

and the outcome is similar when the cofactors of B_4 and C_4 are considered.

(2) As every bordered determinant is already known to be expressible as a bilinear, for example,

$$\begin{vmatrix} a_1 & a_2 & a_3 & a_4 \\ b_1 & b_2 & b_3 & b_4 \\ c_1 & c_2 & c_3 & c_4 \\ d_1 & d_2 & d_3 & . \end{vmatrix} = \begin{matrix} d_1 & d_2 & d_3 \\ -|b_2 c_3| & |b_1 c_3| & -|b_1 c_2| \\ |a_2 c_3| & -|a_1 c_3| & |a_1 c_2| \\ -|a_2 b_3| & |a_1 b_3| & -|a_1 b_2| \end{matrix} \begin{matrix} a_4 \\ b_4 \\ c_4 \end{matrix},$$

an alternative form for the preceding theorem is

$$\begin{vmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{vmatrix} \cdot \begin{vmatrix} d_1 & d_2 & d_3 \\ |b_2 c_3| & -|b_1 c_3| & |b_1 c_2| \\ -|a_2 c_3| & |a_1 c_3| & -|a_1 c_2| \\ |a_2 b_3| & -|a_1 b_3| & |a_1 b_2| \end{vmatrix} = \frac{D_1 D_2 D_3}{c_4} \begin{vmatrix} a_4 & a_1 & a_2 & a_3 \\ b_4 & b_1 & b_2 & b_3 \\ c_4 & c_1 & c_2 & c_3 \end{vmatrix} \begin{vmatrix} A_4 \\ B_4 \\ C_4 \end{vmatrix},$$

where it is curious to note that the two bilinear functions are such that the elements in the square array of the first are the cofactors, in $|a_1 b_2 c_3|$, of the elements in the square array of the second, and the elements in the laterals of the second are the cofactors, in the bordered determinant, of the elements in the laterals of the first.

(3) The theorem thus reached recalls another* in which occur two of the same component parts, namely,

$$\begin{vmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{vmatrix} \cdot \begin{vmatrix} D_1 & D_2 & D_3 \\ a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{vmatrix} \begin{vmatrix} A_4 \\ B_4 \\ C_4 \end{vmatrix} = - \begin{vmatrix} |b_2 c_3| & -|b_1 c_3| & |b_1 c_2| & A_4 \\ -|a_2 c_3| & |a_1 c_3| & -|a_1 c_2| & B_4 \\ |a_2 b_3| & -|a_1 b_3| & |a_1 b_2| & C_4 \\ D_1 & D_2 & D_3 & . \end{vmatrix},$$

and, being thus able to combine the two, we deduce the still more interesting equality,

$$\begin{vmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{vmatrix}^2 \cdot \begin{vmatrix} a_1 & a_2 & a_3 & a_4 \\ b_1 & b_2 & b_3 & b_4 \\ c_1 & c_2 & c_3 & c_4 \\ d_1 & d_2 & d_3 & . \end{vmatrix} = \begin{vmatrix} |b_2 c_3| & -|b_1 c_3| & |b_1 c_2| & A_4 \\ -|a_2 c_3| & |a_1 c_3| & -|a_1 c_2| & B_4 \\ |a_2 b_3| & -|a_1 b_3| & |a_1 b_2| & C_4 \\ D_1 & D_2 & D_3 & . \end{vmatrix},$$

where the two bordered determinants are related in the matter of their elements quite similarly to the two bilinears in §2.

As, however, the first factor on the left-hand side of the theorem which we have quoted is, when general, raised to the power $n-2$, our deduced result in its general form is that *the product of any bordered determinant of the $(n+1)^{th}$ order by the $(n-1)^{th}$ power of the unbordered determinant is expressible as a bordered determinant of the $(n+1)^{th}$ order also.*

(4) We have next to note that the extent of the border in the foregoing need not be restricted to one line: for example,

$$\begin{vmatrix} |a_1 b_2 c_3| \\ a_1 & a_2 & a_3 & a_4 & a_5 \\ b_1 & b_2 & b_3 & b_4 & b_5 \\ c_1 & c_2 & c_3 & c_4 & c_5 \\ d_1 & d_2 & d_3 & . & . \\ e_1 & e_2 & e_3 & . & . \end{vmatrix} = \begin{vmatrix} |a_3 b_4 c_5| & -|a_2 b_4 c_5| & |a_1 b_4 c_5| \\ |a_1 b_2| & |a_1 b_3| & |a_2 b_3| \\ |a_1 c_2| & |a_1 c_3| & |a_2 c_3| \\ |b_1 c_2| & |b_1 c_3| & |b_2 c_3| \end{vmatrix} \begin{vmatrix} |c_1 d_2 e_3| \\ -|b_1 d_2 e_3| \\ |a_1 d_2 e_3| \end{vmatrix}$$

* 'Trans. R. Soc. Edinburgh,' xxxii (1885), § 35.

and a quite similar mode of proof suffices. Thus, taking the aggregate of the first three of the nine terms on the right, namely,

$$\left\{ |a_3 b_4 c_5| |a_1 b_2| - |a_2 b_4 c_5| |a_1 b_3| + |a_1 b_4 c_5| |a_2 b_3| \right\} \cdot |c_1 d_2 e_3|$$

we see that it

$$\begin{aligned} &= \begin{vmatrix} a_1 & a_2 & a_3 & a_4 & a_5 \\ b_1 & b_2 & b_3 & b_4 & b_5 \\ c_1 & c_2 & c_3 & c_4 & c_5 \\ a_1 & a_2 & a_3 & . & . \\ b_1 & b_2 & b_3 & . & . \end{vmatrix} \cdot |c_1 d_2 e_3| \\ &= \begin{vmatrix} . & . & . & a_4 & a_5 \\ . & . & . & b_4 & b_5 \\ c_1 & c_2 & c_3 & c_4 & c_5 \\ a_1 & a_2 & a_3 & . & . \\ b_1 & b_2 & b_3 & . & . \end{vmatrix} \cdot |c_1 d_2 e_3| \\ &= |a_4 b_5| \cdot |a_1 b_2 c_3| \cdot |c_1 d_2 e_3|, \end{aligned}$$

which is also one of the three terms got on the left by using Laplace's expansion on the five-line determinant.

The order of the square array of the bilinear depends on the order of the initiating determinant and the breadth of the border; for example,

$$\begin{vmatrix} a_1 & a_2 & a_3 & a_4 \\ b_1 & b_2 & b_3 & b_4 \\ c_1 & c_2 & c_3 & c_4 \\ d_1 & d_2 & d_3 & d_4 \end{vmatrix} \begin{vmatrix} a_1 & a_2 & a_3 & a_4 & a_5 & a_6 \\ b_1 & b_2 & b_3 & b_4 & b_5 & b_6 \\ c_1 & c_2 & c_3 & c_4 & c_5 & c_6 \\ d_1 & d_2 & d_3 & d_4 & d_5 & d_6 \\ e_1 & e_2 & e_3 & e_4 & . & . \\ f_1 & f_2 & f_3 & f_4 & . & . \end{vmatrix}$$

is equal to the bilinear whose square array is

$$\begin{vmatrix} |a_1 b_2| & |a_1 b_3| & \dots & |a_3 b_4| \\ |a_1 c_2| & |a_1 c_3| & \dots & |a_3 c_4| \\ \dots & \dots & \dots & \dots \\ |c_1 d_2| & |c_1 d_3| & \dots & |c_3 d_4| \end{vmatrix}$$

and whose laterals are

$$|a_3 b_4 c_5 d_6|, -|a_2 b_4 c_5 d_6|, |a_2 b_3 c_5 d_6|, |a_1 b_4 c_5 d_6|, -|a_1 b_3 c_5 d_6|, |a_1 b_2 c_5 d_6|,$$

and

$$|c_1 d_2 e_3 f_4|, -|b_1 d_2 e_3 f_4|, |b_1 c_2 e_3 f_4|, |a_1 d_2 e_3 f_4|, -|a_1 c_2 e_3 f_4|, |a_1 b_2 e_3 f_4|.$$

The general theorem may with useful enough fulness be enunciated as follows: *The product of an n-line determinant by the determinant got from it by bordering with r rows and r columns is expressible as a bilinear function whose quasi variables are the n-line minors of the multiplier that contain the bordering rows and the n-line minors that contain the bordering*

columns, and whose square array is that of the r^{th} compound of the original determinant.

(5) When we pass on to the case where the initiating determinant is axisymmetric and is axisymmetrically bordered, another previously known theorem can be brought into service with advantage, namely, the theorem regarding the determinant whose matrix is the sum of an axisymmetric and a zero-axial skew matrix. The 3rd order being taken this theorem is *

$$\begin{vmatrix} a & f + \nu & e - \mu \\ f - \nu & b & d + \lambda \\ e + \mu & d - \lambda & c \end{vmatrix} = \begin{vmatrix} a & f & e \\ f & b & d \\ e & d & c \end{vmatrix} + \begin{vmatrix} \lambda & \mu & \nu \\ a & f & e \\ f & b & d \\ e & d & c \end{vmatrix}.$$

Returning then to our first result above, and taking g, h, k for the border of the basic determinant here, we have

$$- \begin{vmatrix} a & f & e \\ f & b & d \\ e & d & c \end{vmatrix} \cdot \begin{vmatrix} a & f & e & k \\ f & b & d & h \\ e & d & c & g \\ k & h & g & . \end{vmatrix} = \begin{vmatrix} K & H & G \\ a & f & e \\ f & b & d \\ e & d & c \end{vmatrix} \begin{vmatrix} K \\ H \\ G \end{vmatrix},$$

and consequently, by the theorem just recalled,

$$\begin{vmatrix} a & f + G & e - H \\ f - G & b & d + K \\ e + H & d - K & c \end{vmatrix} = \begin{vmatrix} a & f & e \\ f & b & d \\ e & d & c \end{vmatrix} - \begin{vmatrix} a & f & e \\ f & b & d \\ e & d & c \end{vmatrix} \begin{vmatrix} a & f & e & k \\ f & b & d & h \\ e & d & c & g \\ k & h & g & . \end{vmatrix}.$$

an unexpected result in pure determinants.

(6) When the determinant with the peculiar matrix referred to at the beginning of §5 is of the 4th order, there is in the expansion an additional term of a quite different type, namely, we have—

$$\begin{vmatrix} a & g + w & f - v & l + u \\ g - w & b & e + z & k - y \\ f + v & e - z & c & h + x \\ l - u & k + y & h - x & d \end{vmatrix} = \begin{vmatrix} a & g & f & l \\ g & b & e & k \\ f & e & c & h \\ l & k & h & d \end{vmatrix} + P + \begin{vmatrix} w - v & u \\ z - y & x \end{vmatrix}^2,$$

where P is the bilinear whose square array is that of the 2nd compound of the 4-line axisymmetric determinant, and whose laterals are

$$x, y, z, u, v, w.$$

On account of the existence of the said additional term

$$(xw - yv + zu)^2$$

it might fairly be expected that the deduced theorem would no longer hold, or, at least, not in the same form as before. Considerable importance therefore attaches to the value which this additional term assumes when

* 'Trans. R. Soc. Edinburgh,' xxxix (1897), p. 222.

x, y, z, u, v, w are given the values which they hold in our theorem above. Now, even where the basic determinant is not axisymmetric but is $|a_1 b_2 c_3 d_4|$, as at the close of §4 above, we have

$$= |a_5 b_4 c_3 d_6| |a_1 b_2 c_5 d_6| - |a_2 b_4 c_5 d_6| |a_1 b_3 c_5 d_6| + |a_2 b_3 c_5 d_6| |a_1 b_4 c_5 d_6|,$$

and this being an extensional of

$$|a_3 b_4| |a_1 b_2| - |a_2 b_4| |a_1 b_3| + |a_2 b_3| |a_1 b_4|$$

must vanish identically as the latter is known to do.

RONDEBOSCH, S.A.;

27 April, 1921.

COMMENTS ON DR. PÉRINGUEY'S NOTE ON WHALES.

BY ARTHUR F. BEARPARK.

(With one Text-figure.)

With reference to the note on whales by Dr. Péringuey, published in the 'Transactions of the Royal Society of South Africa,' vol. ix, pt. 1, I feel that certain statements contained therein cannot be allowed to pass without challenge.

To deal *seriatim* with the points in question, I will first draw attention to the fact that the size of a whale cannot be safely estimated from the size of its jawbones. The most notable factors affecting the size of the jawbones are the age and sex of the animal, therefore more evidence is required before a length can be assumed for the particular whale which Dr. Péringuey describes (p. 73) as about 100 ft. long.

Balenoptera borealis (p. 74).—It is not easy to understand why Dr. Péringuey should say this whale was considered as rare in the Northern Hemisphere. The very name suggests the North. Those who have studied whales look upon *B. borealis* as a very common species occurring in both hemispheres. For instance, Lydekker, in his 'Guide to Whales,' etc., exhibited in the British Museum, p. 20, records that 771 of these individuals were captured in Finmark in 1885. Further records of *B. borealis* in the waters of the Northern Hemisphere will be found in the publications of—

Salvesen, T. E., 'Journ. Roy. Soc. Arts,' March 29th, 1912, p. 522.

Andrews, R. C., Assistant Curator of Mammals, American Museum of Natural History, "Shore Whaling," 'National Geographic Magazine,' vol. xxii, No. 5, May, 1911, p. 430.

D'Arcy, Wentworth Thompson, 'The Scottish Naturalist,' No. 81, September, 1918, p. 198.

Southwell, T., F.Z.S., 'Seals and Whales of the British Seas,' 1881, p. 77.

Beddard, F. E., M.A., F.R.S., 'Book of Whales,' 1900, p. 155.

Harmer, S. F., Sc.D., F.R.S., 'Cetacea Stranded on British Coasts,' 1915, pp. 5, 6, and 11; 1918, pp. 5, 12, and 13.

Bower, T. W., 'Alaska Fisheries, etc.,' Report of the United States Bureau of Fisheries for 1918. Bureau of Fisheries Document No. 872, p. 64.

Cocks, A. H., M.A., F.Z.S., 'The Zoologist,' London. vol. ix, 1885, No. 100, pp. 135, 141, 143; vol. x, 1886, No. 112, pp. 121, 122, 128, 129, 136; vol. xi, 1887, No. 126, pp. 207, 208, 211, 219, 222; vol. xii, 1888, No. 138, pp. 201, 202, 204, 206, 208.

Therefore, in my opinion, the statement that *B. borealis* was considered rare in northern waters is somewhat misleading.

Feeding habits.—Investigation of the food of whales is a matter of vital importance in studying the great question of the migrations of these mammals, and it is therefore to be regretted that the statements in the note under review about the feeding habits of whales—as to whether they are ichthyophagous or "planctonophagous"—are difficult to reconcile with widely observed facts. Dr. Péringuey states (p. 74) that *B. borealis*, *B. physalus* and *B. musculus* are not planctonophagous, except perhaps occasionally, whereas, as a matter of fact, all these whales regularly feed on the Plankton whilst in South African waters. From an examination of the stomachs of some hundreds of specimens of *B. musculus*, *B. borealis* and *B. physalus* in South Africa, I am in a position to state definitely that it is only on some occasions that fish, or the remains of fish, have been found therein, whereas the small crustaceans are invariably present. I have not, so far, observed any indication of a fish diet in the stomachs of *B. musculus*, and all available literature refers to this whale as feeding solely on the Plankton. In the case of the two other species I am inclined to agree with Andrews ('National Geographic Magazine,' Washington, vol. xxii, No. 5, p. 427), who states that "The whale-bone whales probably never eat fish of any kind if other food is to be had, although there is some evidence that *B. physalus* is in some degree ichthyophagous at certain periods in the Northern Hemisphere, this state of affairs being probably due to partial failure of the Plankton supply. Ichthyophagous whales are easily identified by the presence of fish-scales in the stomach, which scales apparently take a much longer time to digest than either the flesh or bones of the fish. On the other hand, a Plankton-eating whale is, as a rule, very easily identified by the exudation of *terra cotta*-coloured faeces, but if such be not present, an examination of the stomach will instantly determine the question. Dr. Péringuey probably knows that I hold no brief for the Norwegian whalers to whom he refers (p. 75) as being unreliable, yet if he would go for a trip on a whaler, any experienced Norwegian gunner would probably be able to show him Fin, Blue and Sie Whales actually feeding on the Plankton.

If the investigator requires further information about the food of the whalebone whales, I would refer him to the following publications:

D'Arcy, Wentworth Thompson, 'The Scottish Naturalist,' No. 82, October, 1918, pp. 232-233.

Clark, R. S., M.A., B.Sc., 'South Atlantic Whales and Whaling,' 1919. (Shackleton's 1914-1917 Expedition.)

- Jardine, W., F.R.S.E., F.L.S., 'Cetacea,' 1837, pp. 128, 136.
 Burn Murdoch W. G., F.R.S.G.S., 'Modern Whaling and Bear-Hunting,' 1917, p. 254.
 Lydekker, 'Guide to Whales in the British Museum,' pp. 18, 20.
 Beddard, F. E., M.A., F.R.S., 'Book of Whales,' 1900, pp. 154, 156, 158.
 Southwell, T., F.Z.S., 'Seals and Whales of the British Seas,' 1881, p. 77.
 Andrews, R. C., Assistant Curator of Mammals, American Museum of Natural History, "Shore Whaling," 'National Geographic Magazine,' vol. xxii, No. 5, May, 1911 (Washington), pp. 427 and 431.
 Olsen, O., "The Bryde Whale," 'Proc. Zool. Soc. Lond.,' pt. iv, December, 1913, pp. 1073-1090.
 'Report of the Interdepartmental Committee on Research and Development in the Falkland Islands,' pp. 9, 10, 11, 40, 46, 47, 55, 73, 74, 75, 81, 90, 95, 101, 102, 117, 118, 133, 134.

A study of these, along with the information I give, will, I submit, demonstrate that Dr. Péringuey is in error about the feeding habits of the whales.

Dr. Péringuey's conclusion (p. 74), that *B. brydei* is ichthyophagous, is correct, but his premises are wrong. One cannot arrive at a conclusion as to whether a whale feeds on the Plankton or fish from the evidence of the baleen fringe. For instance, this fringe is at least as coarse, or probably coarser in *B. musculus* than in *B. brydei*, but there is no evidence that *B. musculus* is ichthyophagous. All observers agree that the food of the *B. musculus* consists of small crustaceans, therefore Dr. Péringuey's reasoning breaks down in the face of established facts. Olsen states ('Proc. Zool. Soc. Lond.,' pt. iv, December, 1913, pp. 1073-1090) that the food of *B. brydei* consists chiefly of fish, but that it occasionally takes crustaceans, with which observations I agree.

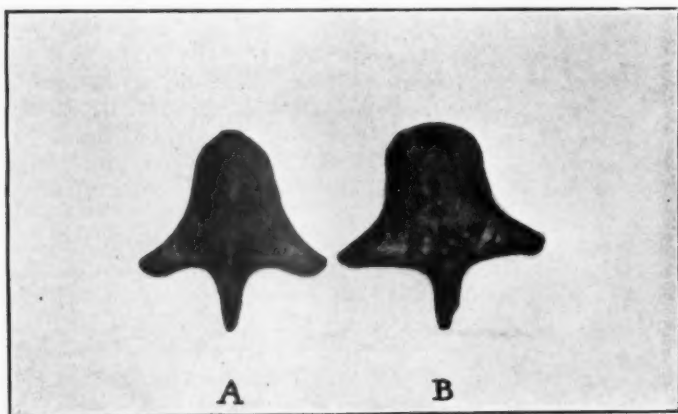
Dr. Péringuey's remarks about the asymmetry of skeletons of Cetacea are by no means clear to me, but the difference in shape of the sterna of *B. borealis* and *B. brydei*, as shown by the photographs, is of considerable interest. Not, however, from the standpoint of demonstrating the specific distinctness of the two mammals, which has already been established, but because the sternum of *B. borealis*, as shown in the photograph, is quite different in shape from the sternum of a normal specimen of this whale. The abnormal form of the breast-bone in the photograph is remarkable, but it is not safe to use this specimen as an example for comparison with the sternum from another species of whale. I submit a photograph showing normal specimens of the sterna of *B. borealis*.

Humpback whales.—I have measured a number of these in South Africa

which have exceeded 50 ft. in length. Such whales are not rare, therefore Dr. Péringuey's statement on p. 75 should be modified.

The statement that this species possesses a penis bone requires confirmation. Eleven humpback whales recently examined by me gave negative results. The alleged penis bone shown in position in the skeleton of the Humpback whale in the South African Museum, Capetown, resembles very closely one of the pelvic bones of a sperm whale.

It is not my intention to speak here on the great question of the possible extermination of whales. I submitted some suggestions for the control of the whaling industry to the Dominions Royal Commission, March, 1914 (Minutes of Evidence, pp. 322-329), and, *inter alia*, the question of Antarctic



A is that of a male 46 ft. 4 in. long.

B is that of a female 51 ft. 9 in. long.

whales migrating northwards in order that their young should be born in comparatively warm seas was discussed.

I would like, however, to remark that there is no evidence which points to any possibility of whales being exterminated. There is, however, reason to believe that the whaling industry will suffer through whales becoming scarcer.

I am dealing elsewhere with the whole question of the preservation of whales and the whaling industry; my object in submitting the present comment is the purely scientific one of endeavouring to apply the test of careful observation to assertions claiming to be fact.

NOTE ON THE PECTORAL FIN OF THE SOLE, *ACHIRUS*
CAPENSIS: ITS ORIGIN AND SIGNIFICANCE.

BY J. D. F. GILCHRIST.

(With Plate IV.)

The changes which take place in the body of flat fish in correlation with alteration of the position of the body are of particular interest from an evolutionary point of view. These changes are not so far back in the genealogy of the animal that we cannot hope for some light on the question of their origin, and the more recent such changes are the more instructive they will be. The following case may therefore be of special interest in this respect. It is also suggestive of some wider problems, such as the origin of paired limbs, on which some remarks are made.

The pectoral fins of the soles have lost their original functions of balancing the body, and we find that their subsequent fate has been very diverse. In some species they become very much enlarged; in others they disappear altogether. This is well illustrated in the South African soles, of which there is a great variety. Among these there is a small sole, *Achirus capensis*, which has been described as devoid of pectoral fins. It is common on the sandy shores of False Bay, and as it can readily be kept in confinement, it is a very suitable subject for the study of colour-adaptation to various surroundings. It was while some experiments of this kind were being made that a peculiar action of the branchial aperture was observed, for, in inspiration, not only did the opercular membrane close down against the body, but a small flap of transparent skin was seen to rise from the body to meet it, thus forming a double valve for the closing of the aperture. Other living specimens were examined, and in all this little valvular membrane was found, apparently functioning as an accessory organ in respiration. On one occasion, however, a number of very small soles of this species was procured, and it was observed that the small flap, though present and well developed, lay applied to the body, and did not function in any way in the process of breathing.

This structure may be best examined in an adult specimen. In one,

128 mm. in length, it is readily seen by raising the membranous border of the operculum, which conceals it. It consists of a transparent fold of skin, which at its upper end is continuous with the opercular membrane. It attains its greatest breadth (1.3 mm.) about 2 mm. from the upper angle of the opercular opening, and from this broader part gradually tapers away, the total length being 7 mm. The whole structure is situated over the clavicle, to which, however, it is not attached, and that it represents a reduced pectoral fin is indicated by the presence of six dermal rays, though no traces of other elements (radials) of the limb are to be seen. These dermal rays are widely set apart, and are so arranged as to form a support for the elongate fold. The rays taper off towards the border, near which they end. This border is slightly emarginate between the distal ends of the rays, the emargination being much more marked in movement in the living condition (Pl. IV, fig. *b*). The two halves of each ray are fused together throughout their length, except at the proximal end, where they appear as short stout forks, the function of which in normal fins is to secure the rays to the radials. As these radials are absent in this case, the meaning of the marked development of these forks here may be interpreted as a device for the more effective control of the valvular pectoral in its movements.

The upper and lower ends of this fin may be particularly noticed (Pl. IV, fig. *a*). At its upper end it is distinctly continuous with the margin of the opercular membrane, and but for the presence of the rays the whole structure might be interpreted as an extension of this margin on to the body. At its lower end it is continued as a rayless membrane, gradually becoming narrower. This rayless part is about half its total length, which is considerable, being about a third of the whole opercular opening.

This structure differs very considerably from the normal fin of fishes. The mesodermal supporting elements of the fin have been lost, the dermal rays reduced in length, though comparatively stout; their proximal ends are well developed and spread out. Though the fin is shorter in length, its base is relatively large, so as to form a thin vertical membrane, which is supported by the altered position of the rays. Not only has the structure of the fin been very much altered, but the function is totally different.

We have therefore here an illustration of the appearance of a new organ, which apparently does not occur in any other fish,* and is of comparatively recent origin.

It can be accounted for, as any modification of the body can be accounted for, by a process of natural selection of favourable germinal variations. Such an explanation cannot, however, with our present knowledge of cell structure and function, either be proved or disproved, and we may meantime look round for some other possible suggestions.

* Since this paper was in print, I have noticed a similar fold, but without rays, in some of the Chimaeridae, and that, in the living *Callorhynchus*, it functions as an accessory valve in respiration.

We may assume that the altered position of the body of the flat fish was not assumed suddenly and by all its members at once, and that it came about probably in correlation with a changing external environment. A change in environment, brought about primarily by a simple change in physical conditions, may be followed by much more complex changes in the actual surroundings of the organism. By way of illustration we may suppose that the first change was a purely physical one, as, for instance, the gradual deposition of mud. Secondary changes would follow, the mud becoming populated by a variety of its characteristic forms of life. These forms in their turn would attract other predatory fish, etc., which feed on them, and so a great many new factors—these and others—would arise which could possibly lead to changes in the ancestral sole. One possibility is suggested by an observation on a particular species of fish, the blenny, *Clinus*, of which there is a great variety at the Cape. It is active in its habits, and preys on other small fish, crabs, etc. Its eyes are well developed, and resemble the motile eyes of the chameleon. In captivity it was seen frequently to seize and devour small mullet swimming above it at the surface, and it was observed that, in order to watch its prey more readily, it frequently lay over on one side, thus directing an eye upwards. It can be readily concluded that if this device is adopted for detecting prey, it will serve equally well for detecting enemies, and may have been adopted by flat fishes; another possible factor is the changed source and changed kind of food, consisting of small animals in the muddy ground. The reason for the change of position need not, however, be considered here, and these possible factors are merely mentioned to indicate how complex the external environment may become. The suggested change in environment by a gradual deposition of mud is also purely illustrative. A change in environment may be brought about in other simple ways, as, for instance, by gradual migration of the animal itself to other localities.

With the change from a vertical to a horizontal position the function of the pectoral fin of maintaining the body in a vertical position would be lost, and, owing to disuse, it would tend to diminish in size. This diminution in size, accompanied probably by more complex physiological changes, would of course appear in the succeeding generation if the identical factors which brought it about in the parent were present, and it follows that if these were more pronounced, as they would be in a changing environment, the effects would be more marked. This process of diminution would be arrested at any stage, in which it began to function in another capacity, as has occurred in the *Achirus*.

It might be suggested that the reduction of the pectoral fin is in co-ordination with the elongation of the body as happens in the case of many fish. This, however, is not the case in *Achirus*, where the body is not elongate, but rather short in proportion to its depth.

If reduction of the fin in length to its present dimensions can thus be accounted for, how can we explain the relative elongation of its base of attachment to the body? Apparently this cannot be explained as an effect of use of this portion of the fin, for, as noted above, in the early stages this feature is well marked, though the organ is functionless. It is then merely a dermal membrane in which rays are not developed. It may be borne in mind, however, that the paired as well as the unpaired fins arise in this way, the membrane being replaced by the permanent fin, whose base of attachment to the body is, as a rule, relatively shorter. The presence of a well-developed though functionless pectoral fin of this nature at an early stage may therefore be accounted for by the facts, or rather the mechanism of development.

A modification of the body acquired in this way by functional and environmental changes would be hard to distinguish from a germinal or "innate" character.

The question as to whether such acquired characters may become fixed in another way, viz. by so affecting the germ-cells that they would be reproduced in succeeding generations, if their original cause were removed, is another though quite legitimate inquiry, namely that of the inheritance of acquired characters.

There are so many pitfalls to be avoided in the discussion of the question of heredity, largely due to the use of terms not strictly defined, that one must walk warily. Thus the word "environment" has been here used in two senses, first as the external surroundings (physical and biological) of the body as a whole, and secondly as the external surroundings of an organ of the body, including the other organs. It is necessary to use the term in the wider sense, for the change in position may not have been in direct co-ordination with a changing external environment, but with some gradual internal change in the organs of the animal itself. With this explanation it will probably be admitted that the acquired characters referred to are transmitted, or rather repeated in succeeding generations, for the same cause acting under the same conditions will produce the same effect. It may even be admitted that the changed environment so defined may become so complex and fixed that these characters will be indistinguishable from hereditary characters, acquired by a process of natural selection of favourable variations which have not been brought about by use and disuse. In this particular case it is not at all obvious that the new organ is of any great advantage to the animal. On account of its accidental position near the ebb and flow of the current of water at the opercular opening it is kept in activity, and, so long as it does not seriously interfere with the normal functions of the body, its continued existence will be tolerated. Other cases apparently of this nature are known in the animal kingdom, and perhaps this may be added to the list.

Whatever the explanation of the process may be, however, there is little doubt but that we have here the reduction of the pectoral fin to a simple fold of the epidermis of the body, lying parallel with and resembling the membranous epidermal border of the operculum. So striking is the resemblance that the idea of their possible homology is suggested, though such resemblance is no proof of homology. The reduction of a pectoral fin to a lateral fold of the body also recalls one of the oldest theories of the origin of paired limbs, and is an inducement to inquire a little further into the matter.

The simplest mechanism of respiration by gill slits would appear to be the establishment of a current of water by ciliated epithelium, as in some of the lowest vertebrates (*Balanoglossus*, Ascidians, *Amphioxus*). In the higher forms, the Cyclostomes, there are gill pouches connected by tubular passages to the exterior, where they open by small rounded apertures, guarded by more or less circular rings of cartilage. In the Elasmobranchs, which are provided with a more expansible pharyngeal cavity for inspiration, there is a simple mechanism consisting of a series of vertical folds which overlap the slit-like external openings of the gills, and act as effective valves, being mechanically closed in inspiration and opened in expiration. These are very well developed in some Elasmobranchs (*Chalamydoselachidae*). In others (*Chimaeridae*) there is a great development of the anterior of these flaps, which grows backwards over the gill openings, and acts as a valve for the whole of the branchial apparatus forming the operculum proper of the fishes.

In bony fishes there is a further elaboration: this enlarged operculum strengthened by dermal bones takes over the functions of inspiration, while the membranous posterior border retains the original valvular function. Further, the bony operculum may come to subserve other functions, chiefly defensive, and, in exceptional cases (*Anabas scandens*), locomotory. We have therefore an illustration of how the simple epidermal flap which covers the external opening of a gill slit may be transformed into a somewhat elaborate organ, modified to perform other than its original functions.

There is some reason to suppose that in the primitive vertebrates the number of gill slits were more numerous, and extended further along the body than in later forms. The reduction in the gill slits began probably in the more posterior; they became closed up, and their gill arches and opercula disappeared, but it is quite possible that some of these opercula may, like the anterior operculum, have become developed into more elaborate organs taking on some other function, and should the evolution of the vertebrate body have been in the direction of a decrease in length and an increase in depth, the function now performed by the paired fins is a likely enough one. How the simple opercular flap could have tided over the critical period when the gill opening which it covered became closed up may be indicated by the

case of the *Achirus*, for it could still perform a valvular function in conjunction with the operculum in front of it, or it may well have been the case that in the primitive vertebrate with its increased number of gill slits, not only the opercular flap of the hyoid arch became enlarged to cover some of the gill clefts, but that this happened also in two of the branchial arches. It need not, however, necessarily find any form of useful activity to justify its continued existence.

It may be significant in connection with this suggested opercular origin of the paired limbs that in the lower vertebrates, such as Cephalochordata and Cyclostomata, in which no opercular flaps are developed, though there are branchial skeletal elements, there is no indication of the existence of paired limbs at any time in their development or life-history.

The origin of paired limbs from such opercula is not a new suggestion, as it is part at least of the hypothesis associated with the name of Gegenbaur, who suggests that the limb-girdle and pterygia are derived from a visceral arch and its rays, and (2) the pinna or distal part from the flaps or external free part of the gill septum. He, however, did not apparently entertain the idea that one of these parts of his theory might be correct while the other might be wrong. Another theory (Graham Kerr) is that external gills were in primitive vertebrates developed on each visceral arch and that these gave rise to the paired limbs. This theory is not inconsistent with Gegenbaur's suggestion that the girdles are derived from visceral arches. A third theory (Balfour) is that the paired limb is derived, not from any external modification of the gill septum, but from an epidermal fold which in primitive vertebrates is supposed to have occurred along each side of the body. It seems to have been generally taken for granted throughout the history of the discussion that this is inconsistent with the derivation of the supporting structures of the limbs from visceral arches, but it is not quite evident that it is necessarily so. It is true that in the elaboration of the lateral fold theory it has been suggested that the differentiation into limb rudiments began at the anterior and posterior regions of the folds, but this is not a necessary corollary of the hypothesis, for the differentiation may have commenced at the anterior extremity in association with a disappearing gill arch, and, on the movement backwards of this combined structure (epidermal fold and supporting visceral arch), the process may have been repeated to give rise to the anterior pair of limbs.

On the other hand, while all three theories look for an external epidermal organ as the origin (in part at least) of paired fins, the derivation of the supporting structures (girdles and radials) from gill arches is not bound up with this origin. Any of the three views in this limited sense are consistent with the origin of these elements *de novo*. Thus even Gegenbaur's or Graham Kerr's hypotheses may be correct so far as the limb proper is concerned, and yet open to question as regards the origin of its supporting structures.

There are many illustrations in the body of how ready the mesoderm is to collaborate with any process initiated by the ectoderm or endoderm, by contributions of muscular or supporting tissues. Examples of this are abundant, for instance, in the elaboration of the nervous system and the sense organs, or, to take a more kindred example, in the provision of the supporting radials for the vertical or unpaired fins. In fact this collaboration and assistance is sometimes carried so far that the mesodermal elements usurp the place and function of the original organs entirely, as, for instance, in the case of the notochord initiated by the endoderm, and perhaps in the apparently primitive pectoral of the Dipnoi initiated by the ectoderm.

The question, therefore, whether or not the skeletal elements of paired fins are derived from the visceral arches or arise as in the case of unpaired fins may be looked upon as supplementary to the question of the origin of fins as such, the origin of radials and girdles being another though interesting and important enough question in itself, particularly in connection with the possible derivation of the skeleton of the pentadactyle limb from that of the fish limb.

If, therefore, we must look to some epidermal structures or superficial modifications of the body as the precursors of paired limbs, we have—(1) external gills whose primary function is respiration, (2) a problematic longitudinal fold of the body with the function, also problematic, of balancing the body, (3) vertical folds of the body, whose function is primarily connected with the mechanism of respiration by gill slits.

With regard to the external gill theory, it may be helpful to keep in view the probable meaning of the external gills or other additional organs of respiration, which appear to have displaced the simple external respiratory organs so characteristic of animals devoid of gill slits. The most obvious significance of the appearance of these simple organs is that the supply of water to the gill slits has in some way or other become partially cut off.

This may occur under various altered conditions of environment, as, for instance, in a prolonged embryonic stage, rendered possible by a more abundant supply of food in the form of yolk. A protecting shell is present in such cases, and this, of course, seriously interferes with the free access of water. In some such cases the yolk and body may become highly vascularised as in the large egg of *Galeichthys feliceps*, which is carried about in the mouth-cavity of the parent and thus has the benefit of its respiratory apparatus, or the egg of the Cape *Bellostoma* in the shell of which there are numerous slit-like apertures. In the pelagic egg of a Cape fish the pectoral fin was observed to be in constant motion—yet another device connected with respiration. Compare the branchial character of the paired limbs in *Ceratodus*.

In other cases, more particularly the embryonic Elasmobranchs, more specialised supplementary respiratory organs are developed in the form of

external gills which project from the gill septum into the surrounding liquid medium. The egg case is constructed so that the water can pass in at one end and out at the other, and, in the somewhat elaborate egg of *Callorhynchus*, there is a very perfect device for providing a current of water, as the long flat tail of the embryo projects into a narrow part of the egg case, and keeps up a constant undulatory movement.

This same diminution of the supply of water may occur in post-embryonic life, and here we find similar devices adopted, both the simple increase of vascular surface and the development of external gills.

Two simple cases of the first which do not seem to have been previously recorded may be mentioned. One is that of a species of Goby (*Trypauchen*) found in masses of mud brought up by dredge off Delagoa Bay on one or two occasions. When alive it was of a bright red colour, which microscopical examination showed to be due to blood contained in a network of fine vessels spread over the whole body under the thin transparent skin. The other is that of the blind deep-sea fish (*Barathronus*), a specimen of which was brought up from a bottom of Globigerina ooze off the Cape. Another example is the highly vascularised skin of the clawed toad, *Xenopus*, which spends most of its life under water.

In post-embryonic stages we may also have the development of external gills, under conditions unfavourable for an adequate supply of oxygen, as, for instance, in the muddy or semi-aquatic environment of the Dipnoi, in which external gills are developed.

It is obvious that a semi-aquatic environment must have been passed through by the numerous vertebrates which now lead a terrestrial life, and these, in all probability, passed through an external gill stage. Further, it is not improbable that migration to the land conditions began as early as migration to the pelagic conditions or at the *Amphioxus-Myxine* stage. (In this connection it may be mentioned that the Cape *Bellostoma* is said to make occasional excursions from its aquatic element.) What more probable than that the primitive limbless vertebrates, equipped with external gills, should, as has been suggested, use these as organs for the support and locomotion of the body under its new conditions of life, and from these the pentadactyle limb be developed?

If the tetrapod limb has been evolved in this way from an external gill, developed in connection with the transition of the primitive aquatic vertebrate to terrestrial life, it can hardly be supposed at the same time that from this organ arose the paired limbs of fishes, developed as organs necessary in the transition to pelagic life, probably in association with the shortening and flattening of the body.

There have been belated attempts among fishes to acquire the terrestrial habits. The most successful, however, such as that of the *Periophthalmus* or *Anabas*, have shown no approach to the acquisition of an organ of terrestrial

locomotion at all similar to the pentadactyle limb. Attempts to trace any structural resemblance between a paired limb of any fish and that of a terrestrial animal cannot be said to have been much more successful.

The theory of the origin of paired limbs from a lateral fold of the body has at least this in its favour—that its suggested function was essentially in the direction of an adaptation for an active pelagic life. The various arguments for and against this theory need not be repeated, and only some points noted which seem to indicate the origin of paired fins from vertical folds rather than lateral folds.

(1) Vertical opercular folds of the epidermis exist in fishes at the present day, and there can be no doubt but that they existed in the primitive vertebrates, in which an expansible pharynx and its associated valvular opercula first appeared, not unlikely before balancing paired limbs suitable for a more pelagic life appeared, whereas, not only does no such longitudinal fold as the hypothesis requires occur in any living fish, but there is no satisfactory embryological or palaeontological evidence that it ever existed.

(2) The function of the vertical folds is an obvious one at the present day, and even a necessity in the first primitive vertebrates, in which the respiratory current of water was drawn in by the mouth by means of an expansible pharynx provided with a framework of jointed branchial arches, whereas the suggested function of the lateral fold, a keel for steadying the body or a parachute-like expansion, are at the best conjectures, the first perhaps not mechanically justifiable.

(3) That such opercular folds may attain greater dimensions is shown in some primitive sharks, and more especially in higher fish, in which they may have assumed the form of large organs taking on other functions, such as assisting in inspiration, acting as defensive and offensive organs or organs of locomotion.

(4) It accounts for the absence of paired limbs in the Cephalochordata and the Cyclostomata in which no opercular folds are developed, and their presence, except when secondarily absent, in all vertebrates in which such folds appear. Gill septa provided with skeletal elements are present in the Cyclostomata as in other fishes, but there are no opercula and therefore (?) no limbs.

A great many objections have been raised to Gegenbaur's theory as to the origin of paired limbs from branchial septa from two points of view, which may be distinguished from each other: first the suggested origin of girdles and radials from the skeletal parts of a gill septum, and second, the implied origin of the distal part of the limb from the gill flap or operculum.

The objections to the first, which appear to be weighty, need not be gone into, but the objections to the second apply equally to the opercular origin and may be considered.

(1) The gill septa with their skeletal elements of the apparently primitive Cyclostomes and Elasmobranchs are fixed, not projecting beyond the surface, and therefore not likely to give rise to external organs like paired limbs. This may be admitted in the case of the Cyclostomata, but it is just these which have no paired limbs. In the case of the Elasmobranchs the opercula are external organs and are well developed in Chladoselachidae and Holocephali.

(2) Another objection to the origin of pectoral fins from vertical folds is that it has been observed in most cases examined that when they arise as folds of the body these are more or less longitudinal in direction, and it is only subsequently that they assume a vertical position, and that by rotation sometimes in one direction, sometimes in another. This certainly does not corroborate this vertical fold origin, but it may be noted that the position of the developing paired limb has not been investigated in many kinds of fish, and that the paired limbs of Elasmobranchs are not necessarily primitive in this respect. In this group and that of the Dipnoi, indeed, the endoskeletal elements seem rather to be taking the place of the primitive fin. In some *Achirus* and in the larval form of a very large South African sole (*Synaptura microlepis*) the rudiments of the pectoral have been observed to be vertical in position.

In this connection, however, another theory of the origin of paired limbs which has been much discussed may be noted, namely, that they arise from a longitudinal lateral fold, not such as Balfour supposed to have occurred in primitive fishes, but as it arises in the formation of the metapleural folds in *Amphioxus* (Thatcher, etc.) These folds now function as a protective covering for the external opening of the gill slits. Evolution of organs is often in the direction of a reduction in numbers in co-ordination with the elaboration of a few, and it is not impossible that with muscular pharyngeal in place of the more primitive ciliary respiration the fold may have become differentiated into valvular opercular flaps for the remaining gill opening. This suggestion is very speculative as is also this theory itself, but it is mentioned as a possibility which might indicate that the origin of paired limbs in ontogeny as longitudinal folds which only later become vertical folds is not so inconsistent with their derivation from opercula as appears.

(3) It is objected that transverse folds across the body, such as the opercula, would rather tend to arrest than to assist in the forward movement of a swimming fish, but it is just for this purpose that paired fins are frequently used, as may be observed in the commonest types of fish in life. With the shortened and deep body assumed by the vertebrates in taking to a free-swimming life there is no such provision for the checking of the forward movement as is found in the more elongate bodies, in which advance or retreat can be effected by a reversal of the undulatory movement of the body and paired fins are necessary for this purpose. This is confirmed by

the tendency in elongate forms for the pectorals to disappear. High speed is usually associated with some means of controlling it.

The checking of forward progress in the primitive limbless vertebrates could be effected by the only available structures, the transverse opercular folds, and it may again be noted that the Cyclostomes which have no such transverse folds or opercula have apparently never advanced to the paired limb stage.

(4) It may be objected that there is no evidence of the free opercular part of the gill septa becoming separated from the more internal part with its supporting skeleton. The evidence against that part of Gegenbaur's theory dealing with the origin of girdles and radials from gill arches and rays is in part a reply to this, and need not be repeated. It has carried so much weight that his whole hypothesis of the origin of paired limbs (from the vertical opercular folds as well as the gill arches) is generally viewed with less favour than the lateral fold hypothesis. His theory might still be partly true, even though the girdles be derived from some one of the other sources which have been suggested—ribs and other organs. (The extra-branchial cartilages, which are well developed in some present-day sharks (*e. g. Odontaspis*) and form the main supports for the gill flaps, are possible sources of the girdles, more especially as they are situated in the somatopleure like the girdles, and not in the splanchnopleure like the visceral arches.) To the evidence already adduced of the possible persistence of the opercula, when gills, gill-clefts and the rest of the gill septum have disappeared, may be added that the operculum of living Teleostei may find other or additional supports, as, for instance, in the *Scleroparsi*, and that in the many cases of reduction of gill clefts the gill arch may be as greatly reduced as the gill cleft.

It might be suggested that the fact that the pectoral fin can become an epidermal fold supports the suggestion that an opercular fold may have become a pectoral fin, as this is merely a reversal of the process. This argument might have had more weight at one time, but recent investigations seem to indicate that such reversals do not occur in the evolution of animal life. This has been inferred from the fact that no clear cases are known, but this inference does not, however, imply the existence of any law, and cannot be advanced as an argument against the above suggestion, if indeed the particular case of the *Achirus* may not point to the possibility of such reversal, at least in measure. The argument, however, is not a good one. It might be used also to indicate that the opercular fold disconnected from the gill septum, for in the case of the *Achirus* the fold has lost its attachment by radials to the shoulder girdle. It might be used also in favour of another suggestion, that paired fins have arisen from median fins, for in several soles the pelvic fin of one side may assume a median position and become continuous with the anal.

Perhaps it may be necessary to note another point of view which has been taken up with regard to this question of the origin of paired limbs. It is pointed out that in development it is the mesodermal elements which seem to take the initiative, that in the origin of the skeletal elements the successive appearance of parts is from within outwards, and that a mere epidermal fold cannot be looked on as the actual origin of limbs, for the real structure of a fin begins only when the supporting mesodermal cartilaginous elements appear. With regard to the first two points, it is true that ontogeny is often a valuable guide in tracing the rise of an organ, but not an infallible one, and with regard to the last, the finished organ is often totally different from its initial phases, as for instance in the case of the axial skeleton of vertebrates. Besides, it is difficult to imagine that an external organ of locomotion originated entirely from an internal structure. It seems, therefore, quite legitimate to discuss the origin of paired fins apart from that of the radials or girdles.

Reviewing the position as a whole with regard to the origin of unpaired fins, apart from the question of the source of their secondary supporting structures, the following hypothesis has been proposed: (1) The external valvular flaps of the gill septum and (2) external gills attached to the gill septum; (3) longitudinal lateral folds of the body conjectures from certain evidences to have been present in some primitive fishes; (4) longitudinal lateral folds such as occur in *Amphioxus*; (5) unpaired fins.

The only one of these which seems entirely exclusive of the others is the last, for which there is little or no evidence. What is suggested is that the paired limbs of fishes arose as modifications of the external gill flaps, called here for convenience valvular opercula, which appeared as separate active external organs in co-ordination with muscular pharyngeal inspiration and expiration, and that these opercula in their turn may have originated as segmental differentiations of a supra-branchial lateral fold, originally used in raising and sustaining the body in the water, and which now appears in ontogeny as more or less disconnected longitudinal folds. This is not opposed to the hypothesis that external gills which are vascularised gill septa may have given rise to the paired limbs of Amphibia and terrestrial animals.

Much more could probably be said in elaboration of the supposed opercular origin of paired limbs. Thus a specially pleasing feature, and therefore perhaps to be regarded with caution, is that it appears to account for the absence of paired limbs in the Cyclostomes which have a branchial arch skeleton but no opercula, and shows that this negative feature is not secondary but essentially connected with one of the three fundamental characters of the Chordata, namely pharyngeal respiration by gill slits: in fact the phylum could be divided into two sub-phyla on the basis of its pharyngeal respiratory system and its derivatives (paired limbs) thus:

(a) CYMNOPLEURA, with simple respiratory mechanism and no opercula nor limbs, including Hemichorda, Cephalochorda, Urochorda and Cyclostomata, each of which might also be rearranged on the same basis.

(b) CLADOPLEURA, with complex respiratory mechanism and paired limbs, including fishes with paired limbs derived from opercula (Tetraptera), and Amphibia, etc., with paired limbs derived from opercula modified as external gills (Tetrapoda).



a. Pectoral fin of *Achirus capensis*, *a.*, cut out from preserved specimen ($\times 12$ ca.); *b.*, in living specimen in expiration, and *c.*, in inspiration ($\times 4$ ca.). *op.*, operculum; *op.m.*, opercular membrane; *p.*, pectoral fin; *r.*, ray of pectoral.

ON THE SENONIAN AMMONITE FAUNA OF PONDOLAND.

By L. F. SPATH, D.Sc., F.G.S.

(With five Plates.)

CONTENTS.

A INTRODUCTION	114	SUB-FAMILY PACHYDISCINAE:	
B. DESCRIPTION OF SPECIES	117	Genus PARAPACHYDISCUS, Hyatt:	
FAMILY PHYLLOCERATIDAE:		17. <i>P. aff. ootacodensis</i> ,	
Genus PHYLLOCERAS, Suess:		Stoliczka sp.	132
1. <i>Ph. woodsi</i> , v. Hoepen	117	18. <i>P. simplex</i> , v. Hoepen	
2. <i>Ph. umzambiense</i> , v.		sp.	133
Hoepen	117	19. <i>P. umtafunensis</i> (Crick	
FAMILY LYTOCERATIDAE:		MS.), Spath	133
Genus GAUDRYCERAS, Grossouvre:		20. <i>P. antecursor</i> , v. Hoepen	
3. <i>G. tenuilineatum</i> , v.		sp.	133
Hoepen	117	21. <i>P.?</i> sp. nov.?	134
4. <i>G. varicostatum</i> , v.		SUB-FAMILY KOSSMATICERA-	
Hoepen	117	TINAE:	
5. <i>G. cinctum</i> (Crick MS.),		Genus MADRASITES, Kilian and	
Spath	118	Reboul:	
6. <i>G. amapondense</i> , v.		22. <i>M. natalensis</i> (Crick MS.),	
Hoepen	118	Spath	134
7. <i>G. sigcau</i> , v. Hoepen	118	23. <i>M. acuticostatus</i> (Crick	
Genus TETRAGONITES, Kossinat:		MS.), Spath	134
8. <i>T. superstes</i> , v. Hoepen	119	24. <i>M. faku</i> , v. Hoepen	
9. <i>T. nuperus</i> , v. Hoepen	119	sp.	135
Genus PSEUDOPHYLLITES, Koss-		25. <i>M. africanus</i> , v. Hoepen	
mat:		sp.	135
10. <i>P. indra</i> (Forbes).	119	26. <i>M. aff. africanus</i> , v.	
FAMILY DESMOCERATIDAE:		Hoepen sp.	135
SUB-FAMILY PUZOSINAE:		27. <i>M. sp. ind.</i>	135
Genus PARAPUZOSIA, Nowak:		28. <i>M. similis</i> , Spath.	135
11. <i>P. haughtoni</i> , nov.	128	<i>Incertae sedis</i> —	
Genus SCHLÜTERIA, Grossouvre:		Genus HOPLOSCAPHITES, Nowak:	
12. <i>S. simplex</i> , v. Hoepen sp.	129	29. <i>H. sp.</i> (cf. <i>similaris</i> ,	
13. <i>S. crassa</i> , v. Hoepen sp.	129	Stoliczka ?)	136
Genus HAUCERICERAS, Grossouvre:		30. <i>H. sp.</i> (cf. <i>pavana</i> ,	
14. <i>H. gardeni</i> , Baily sp.	129	Forbes ?)	136
15. <i>H. remba</i> , Forbes sp.	131	31. <i>H. sp. nov.</i> ?	136
16. <i>H.?</i> <i>sugata</i> , Forbes sp.	131	32. <i>H. sp. ind.</i>	136

FAMILY 'PRIONOTROPIDAE':

Genus MORTONICERAS, Meek:

33. *M. soutoni*, Baily sp. . . 136
 34. *M. stangeri*, Baily sp. . . 137
 35. *M. stangeri* (Baily), var.
sparsicosta, nov. . . 138
 36. *M. stangeri* (Baily), var.
densicosta, nov. . . 138

Genus PSEUDOSCHLOENBACHIA,

Spath:

37. *P. umbulazi*, Baily sp. . . 139
 38. *P. pseudofournieri*, nov. . 140
 39. *P. papillata* (Crick MS.),
 Spath 141
 40. *P. griesbachi* (Crick MS.),
 Spath 141

Incertae sedis—

41. Gen. nov. (*Muniericeras*?)
cricki, Spath 141

Genus EULOPHOCERAS, Hyatt:

42. *E. natalense*, Hyatt . . . 142

Genus SPHENISCOCERAS (Crick

- MS.), Spath 142
 43. *S. africanum* (Crick MS.),
 Spath 143

44. *S. tenue* (Crick MS.),
 Spath 144
 45. *S. minor* (Crick MS.),
 Spath 144
 46. *S. amapondense*, v.
 Hoepen sp. 144
 47. *S. umzambiense*, v.
 Hoepen sp. 145

FAMILY NOSTOCERATIDAE:

Genus BOSTRYCHOCERAS, Hyatt:

48. *B. ? amapondense*, v.
 Hoepen sp. 145

Genus DIPLOMOCERAS, Hyatt:

49. *D. ? indicum* (Forbes) . . 145

Genus OXYBELOCERAS, Hyatt:

50. *O. amapondense*, v.
 Hoepen sp. 145

Genus NEOCRIOCERAS, Spath:

51. *N. cf. spinigerum*, Jimbo
 sp. 146

FAMILY BACULITIDAE:

Genus BACULITES, Lamarck:

52. *B. capensis*, Woods . . . 146
 53. *B. sulcatus*, Baily . . . 146
 54. *B. bailyi*, Woods 146

A. INTRODUCTION.

In the description of the Upper Cretaceous fauna of Umkwelane Hill in Zululand,* and in a paper on "Upper Cretaceous Ammonoidea from Pondoland," † reference was made by the writer to a collection of Pondoland Cephalopoda in the British Museum (Natural History). This collection was presented by the Natal Government, through Sir F. Abel, in 1894, ‡ and the fossils were referred to by Kossmat, § who examined them in the same year. The late Mr. G. C. Crick described part of this collection, and the writer originally had the intention of revising and completing the MS. The description, apparently, was begun some time after Kossmat's visit, but before the publication of Mr. Woods's "Cretaceous Fauna of Pondoland"; || for, e.g., a specimen of *Baculites* had been given a new name by Crick, which was altered to *B. capensis* after the appearance of Woods's

* "Cretaceous Cephalopoda from Zululand," *Annals S.A. Mus.*, xii, pt. vii, No. 16, 1921, p. 223.

† *Annals Durban Mus.*, iii, pt. 2, 1921, p. 39.

‡ See *Catal. Natal Contrib. Colon. and Indian Exhib.*, 1886, p. 44.

§ "Die Bedeut. d. Südind. Kreideform," *Jb.K.K.R.A.*, xlv (1894), Hefte 3 und 4, (1895), pp. 463-4; also *Rec. Geol. Survey India*, xxviii (1895), pt. 2, p. 42.

|| *Annals S.A. Mus.*, iv, pt. vii, No. 12, 1906.

monograph in 1906. In this paper * Woods also mentioned that Crick hoped to give an account shortly of other Pondoland species of *Eulophoceras* in the British Museum. The omission of any reference to this genus, proposed by Hyatt in 1903, in the (meaningless) description of the new genus *Spheniscoceras* as "intermediate between *Placenticeras* and *Sphenodiscus*," may indicate that Crick's account was written before 1903; a copy of Hyatt's description of the genus *Eulophoceras*, however, was added at the end of the MS. by Mr. Crick with the remark, "Not represented in this collection." This the writer is at a loss to understand, considering the close affinity, if not identity, with *Eulophoceras*, of Crick's genus *Spheniscoceras*. There are, also, discrepancies, e.g. in the naming of some of the forty-three examples of *Mortonicerias*, none of which is described in the MS.; but a revision of Crick's MS. has now become unnecessary, for recently Dr. van Hoepen † dealt with many of the forms described by Crick. Accordingly, only a few short extracts from Crick's MS. will here be given, and it is hoped that a general account of the collection and a revision of the generic nomenclature of all the Pondoland Ammonoidea will prove of general interest.

It has been considered advisable to include in the present paper a review of the very important genera *Pachydiscus* and *Parapachydiscus*. When describing some of the forms of this group in the "Cretaceous Cephalopoda from Zululand," the writer recognised that Nowak's ‡ treatment of the genus *Pachydiscus*, including in that one polyphyletic genus a host of Upper Cretaceous Ammonites of many horizons, was unsatisfactory. Much additional work, however, remained to be done, and even now, in the absence of original material, it is feared that the interpretation of a number of species here referred to must be based merely on the published descriptions and figures. The genotype species, however, or at least representative forms of the various lineages here recognised, are preserved in the British Museum collections. This revision was necessary to enable the writer to place some undescribed new forms, simply labelled "*Pachydiscus*" by Mr. Crick, but is provisional. The whole family *Desmoceratidae*, with its trachyostracous descendants, including the "*Prionotropidae*," will be dealt with in the writer's forthcoming "Monograph of the Gault Ammonites."

After the writer's observations on the Pondoland fauna § were penned, an account of the stratigraphy of the Umzamba Beds by Mr. W. J. Plows

* *Annals S.A. Mus.*, iv, pt. vii, No. 12, 1906, p. 337.

† "Cretaceous Cephalopoda from Pondoland," *Ann. Transv. Mus.*, viii, 1921, pt. 1.

‡ "Untersuch. ü. d. Cephalop. d. Ob. Kreide in Polen," pt. iii, *Bull. Acad. Sc. Cracovie, Cl. Sc. Math. et Natur., sér. B, Sc. Nat.*, Juin 1913, pp. 337 and ff.

§ *Loc. cit.* (Pondoland), pp. 53-56.

was published.* His paper is of interest, since he records *Mortoniceras soutoni* from bed 14, which is considerably higher than the basement bed from which the Survey had recorded *Pseudophyllites indra*. Mr. Plows also points out that this basement bed "is visible for the whole length of exposure at low tide, and is also probably the basement on the right bank of the river." † There should then have been no difficulty in identifying this basement bed. The writer also agrees with Mr. Plows in considering that the fossil contents of these beds could and should be zoned.

Dr. van Hoepen‡ is "inclined to regard the Pondoland Beds as of Upper Santonian age." But it should be pointed out that the type of Grossouvre's *Gaudryceras rouvillei*,§ which species was cited by Dr. van Hoepen, is from an unknown horizon, whereas the very immature specimen of fig. 10, of Upper Santonian age, is more depressed than *G. sigcau*, v. Hoepen. According to Dr. van Hoepen, there are also differences in the suture-line. Again, the South African species of *Schlüteria* do not resemble the type of Grossouvre's *Desmoceras pyrenaicum*. "*Lenticeras*" *jullieni*, Pervinquièrè, is not considered to be related to the Pondoland genus *Spheniscoceras*, which has priority before Dr. van Hoepen's "*Pelecoidiscus*"; and "*Schloenbachia*" *fournieri*, Grossouvre,|| was on a previous occasion characterised by the writer as being more nearly allied to *Gauthiericeras*¶ of the Coniacian. The Pondoland deposits, or rather the great majority of the Ammonites, may thus still be considered to be of Uppermost Senonian, or more precisely of "Campanian plus Maestrichtian" age, as stated in the writer's previous accounts, where it was pointed out that the five known zones of this Upper Senonian and Maestrichtian probably represent only part of the true succession of horizons. The chances, then, are that a fauna like that of Pondoland, which does not quite agree with, *e.g.*, either the Upper Campanian of Galicia or the Valudayur Group of Southern India, if homogeneous at all, may belong to a hitherto unrecognised intermediate horizon or even horizons. Perhaps, since non-sequences are possible, these horizons are not even consecutive.

The writer's thanks are due to Dr. A. Smith Woodward and to Dr. F. A. Bathurst of the British Museum, to Mr. Henry Woods of the Sedgwick Museum, Cambridge, to Dr. Rogers, to Dr. Perringuey, and to Mr. E. C. Chubb for assistance in various ways.

* "The Cretaceous Rocks of Pondoland," *Annals Durban Mus.*, iii, pt. 2, pp. 58-66, pl. viii.

† *Ibid.*, p. 62.

‡ *Loc. cit.*, p. 45.

§ "Les Ammon. d. l. Craie Supér.," *Mém. Carte Géol. Dét. France*, II, Pal., 1893 (4), p. 228, pl. xxxvii, fig. 7.

|| *Ibid.*, p. 112, pl. xxxv, fig. 1.

¶ *Loc. cit.* (Zululand), p. 240.

B. DESCRIPTION OF SPECIES.

FAMILY PHYLLOCERATIDAE.

Genus PHYLLOCERAS, Suess.

1. *Phylloceras woodsi*, v. Hoepen.

1921. *Phylloceras woodsi*, v. Hoepen, *loc. cit.*, p. 3, pl. ii, figs. 1-6, text-fig. 1.

1921. *Phylloceras nera* (Forbes), Spath, Pondoland, p. 40.

The writer examined only one immature example of this species, but Dr. van Hoepen has since shown that the Pondoland form differs in suture-line from the Indian type.

2. *Phylloceras umzambiense*, v. Hoepen.

1920. v. Hoepen, "Descr. of some Cret. Amm. from Pondoland," Ann. Transvaal Mus., vii, pt. ii, p. 142, pl. xxiv, figs. 1-3.

1921. Spath, Pondoland, table, p. 50.

This is a more inflated form than the last, and was compared by the writer to the Patagonian form of *Ph. 'nera'*, described by Paulcke, and to *Ph. pergensis*, Grossouvre sp. = *Ph. velledae*, Sharpe non Michelin sp.

FAMILY LYTOCERATIDAE.

Genus GAUDRYCERAS, Grossouvre.

3. *Gaudryceras tenuilineatum*, v. Hoepen.

1921. *Gaudryceras tenuilineatum*, v. Hoepen, *loc. cit.*, p. 5, pl. ii, figs. 7-9, text-fig. 2.

? 1921. *Gaudryceras*, sp. juv., Spath, *loc. cit.*, p. 41.

The immature example described by the writer may belong to the finely striated species established by Dr. van Hoepen, but it differs in dimensions. The latter are nearer those of *G. varicostatum*, v. Hoepen, but in this species and in *G. cinctum* (Crick MS.) the striation is coarser.

4. *Gaudryceras varicostatum*, v. Hoepen.

1921. *Gaudryceras varicostatum*, v. Hoepen, *loc. cit.*, p. 7, pl. ii, figs. 10-12, text-figs. 3-4.

1921. *Gaudryceras kayei* (Forbes), Spath, *loc. cit.*, table to p. 50.

Dr. van Hoepen may be right in including in *G. varicostatum* the *A. kayei* recorded by Griesbach and figured by Woods. The writer compared this

species to *G. pulchrum*, Crick, which has the dimensions of van Hoepen's species, but six labial ridges on the outer whorl.

5. *Gaudryceras cinctum* (Crick MS.), Spath.

(Plate IX, figs. 3a, b.)

1921. Spath, Pondoland, *loc. cit.*, pp. 41-2, and table to p. 50.

This species is represented by a single, well-preserved example (No. C 19415), the dimensions of which are 64.5—40—37—34. Mr. Crick's long description of this form is not given, since the species is extremely close to *G. varicostatum*, v. Hoepen, and may only be the adult of the latter form. *G. varicostatum*, however, at a smaller diameter, has $H > Th$, and has a larger umbilicus. Crick also had compared his species to Griesbach's *A. kayei*, Forbes. The whorls of *G. cinctum*, however, are fewer, and the striation is coarser than in the typical Pondicherry examples of *G. kayei* in the British Museum.

The writer compared this species to *G. mite* (Hauer), which is very close, but according to de Grossouvre * belongs to the Santonian.

G. varagurense, Kossmat, which had been thought by Crick to be very close to *G. cinctum*, has much finer ornamentation, and a different rib-curve. *G. varagurense*, var. *patagonica*, Paulcke,† is comparatively involute.

6. *Gaudryceras amapondense*, v. Hoepen.

1920. v. Hoepen, *loc. cit.*, p. 143, pl. xxiv, figs. 4 and 5.

1921. Spath, *loc. cit.*, table to p. 50.

The holotype of this species, compared by the writer to *G. colloti*, Grossouvre, and *G. glaneggense* (Redtenbacher), has its inner whorls too badly preserved for exact determination, but is more involute than *G. cinctum*. Its ornament is also far less regular.

7. *Gaudryceras sigcau*, v. Hoepen.

1921. *Loc. cit.*, p. 9, pl. ii, figs. 13-16, text-fig. 5.

This species is based on immature specimens, compressed already at a very early stage, and thus different from any of the known Pondoland forms of *Gaudryceras*.

* Craie Supér., 1894, pp. 227-8.

† "Ceph. d. Ob. Kreide S. Patagon.," Ber. Naturf. Ges. Freiburg i. B., xv, 1907. p. 6, pl. xvii (viii), figs. 1-2.

Genus TETRAGONITES, Kossmat.

8. *Tetragonites superstes*, v. Hoepen.

(Plate VI, fig. 6.)

1921. *Tetragonites superstes*, v. Hoepen, *loc. cit.*, p. 10, pl. ii, figs. 17-20, text-fig. 6.

1921. *Tetragonites cf. epigonum* (Kossmat), Crick, in Spath, *loc. cit.*, p. 42.

The figured example, clearly belonging to v. Hoepen's species, is the specimen (No. C 19416) referred to by the writer, but the *Tetragonites* (?) sp. ind. described in the same place may be a young (and crushed) *Pseudophyllites*.

9. *Tetragonites nuperus*, v. Hoepen.

1921. *Tetragonites nuperus*, v. Hoepen, *loc. cit.*, p. 13, pl. iii, figs. 3 and 4, text-fig. 8.

? 1921. *Tetragonites aff. cala* (Forbes), Spath, *loc. cit.*, p. 43.

This species differs from Forbes's type in having greater inclusion and constrictions that describe a slightly different curve. The example compared by the writer to the Valudayur specimens in the British Museum may be still closer to Forbes's species, but is more evolute than the example figured by Woods.* The suture-lines of all these forms of *Tetragonites* are very similar.

Genus PSEUDOPHYLLITES, Kossmat.

10. *Pseudophyllites indra*, Forbes sp.

1906. *Pseudophyllites indra* (Forbes), Woods, *loc. cit.*, p. 334, pl. xli, fig. 6.

? 1920. *Tetragonites teres*, van Hoepen, "Descr. of some Cret. Amm. from Pondoland," Ann. Transvaal Mus., vii, pt. ii, p. 144, pl. xxv, figs. 1 and 2.

1921. *Tetragonites* (?) sp. ind., Spath, *loc. cit.*, p. 42, pl. vii, fig. 3.

1921. *Pseudophyllites indra* (Forbes), *ib.*, table to p. 50.

? 1921. *Tetragonites virgulatus*, v. Hoepen, *loc. cit.*, p. 11, pl. iii, figs. 1 and 2, text-fig. 7.

This well-known and widely distributed species is represented in the present collection by three specimens (No. C 19417-9), the largest of which Crick described as being, "as Kossmat has already stated, by far the largest

* "Cret. Fauna of Pondoland," Ann. S. Afr. Mus., iv, No. 12, 1906, p. 335, pl. 41, fig. 7.

example of the species yet known. It is 290 mm. in diameter (nearly 11½ inches), and its greatest thickness 148 mm.; there are indications of the former existence of at least another half whorl, so that the specimen when complete must have attained a very large size. The specimen is entirely septate, and the portion of the whorl that is missing was probably occupied by the body-chamber."

"Another example (No. C 19418) is only 70 mm. in diameter, but is without doubt referable to the same species."

"A third example (No. C 19419), in a somewhat harder and darker sandstone, appears to be referable to this species. At first sight it seems to be more compressed, and to have less rapidly increasing whorls and a steeper umbilical wall than *Pseud. indra*, but these differences may in part be due to the imperfection of the anterior part of the outer whorl. Portions of the mouth-border are preserved on each side, and these show that the aperture was very oblique, the ventral (peripheral) portion being projected considerably forward. The body-chamber is seen to occupy rather more than one half of the outer whorl."

FAMILY DESMOCERATIDAE, Zittel.

The genera *Pachydiscus*, *Parapachydiscus*, *Parapuzosia*, *Kossmaticeras*, and the many allied developments discussed in the following pages can all be derived from Desmoceratid stocks that persisted during the Upper Cretaceous, and the unmodified types of which, owing to lack of exact information, are at present included in the genus *Puzosia*, Bayle, though the latter really should be restricted to the Upper Albian-Cenomanian *planulata*-group. Some of these Puzosid developments will be referred to below, under *Puzosinae*, a convenient but polyphyletic assemblage of successive waves of modified Phylloceratids; but with regard to the *Pachydiscinae*, a sub-family that includes a number of developments of *Puzosinae*, the genus

PACHYDISCUS, Zittel,

is here taken to include only the group of *P. peramplus*, Mantell sp., as suggested by Kilian and Reboul* after Pervinquièrre and other writers. Other species of this genus are: *P. prosperianus*, d'Orbigny sp., *P. lewesiensis*, Mantell non Sharpe sp., *P. catinus*, Mantell sp., *P. rhodanicus*, Roman and Mazeran, *P. juvenis*, Laube and Bruder sp., *P. vaju*, Stoliczka sp., and probably *P. seppenradensis*, Landois. *A. undatus*, J. de C. Sowerby,†

* "Les Céphalop. Néocrét. des Îles Seymour et Snow-Hill," Wiss. Ergebn. Schwed. Südpol. Exp., iii, pt. vi, 1909, p. 41.

† Min. Conch., vi, 1827, p. 134, pl. dlxix, fig. 2, B.M., No. 43940a.

which Sharpe * long since had considered to be "better omitted from our lists," may be a crushed *Pachydiscus* of this group. "*Pachydiscus*" *vectensis*, Sharpe sp., like Sowerby's *A. cinctus*, apparently is based on a malformation. Whether the supposed Turonian *Pachydiscus laevicaniculatus* (Roemer), Lasswitz, † belongs to this restricted *Pachydiscus* seems doubtful.

The simple suture-line, with its small external saddle, and the specialisation in size mark this genus as a very distinct assemblage of closely allied forms. Nowak derived it from *Uhligella*, but strong costation appears repeatedly in Desmoceratidae during the Cretaceous, not only in the Aptian, to which formation the true *Uhligella* is restricted, though probably the *Pachydiscus* ancestor is nearly related to such a Puzosid as that figured by Pervinquière as *Pachydiscus* sp. ‡ and quoted by Nowak §. This stock continued into the Senonian, and gave rise, in addition to *Kossmaticeras*, to at least two more developments, resembling the young *Pachydiscus perampus*, namely, *Nowakites*, mentioned below, which attaches itself to such forms as '*Puzosia*' *le marchandi*, Grossouvre, || of the Lower Senonian, and the later *Canadoceras*, which is a close ally of the Puzosid group here separated as *Kitchinites*.

PSEUDOJACOBITES, gen. nov.,

is here proposed for those Turonian forms that, like *P. farmeryi*, Crick sp. (genotype: "Two Cephalopods from the Chalk of Lincolnshire," Geol. Mag., N.S., decade v, vol. vii, 1910, p. 345, pl. xxvii, figs. 1, 2, B.M., No. C 12220), develop multituberculation, and attach themselves to the true *Pachydiscus*, possibly via such forms as '*Pachydiscus*' *anapadensis*, Kossmat sp. The exact relations, however, of this latter form, as of '*P.*' *rotalinus*, Stoliczka sp., which Kossmat thought might come from the same beds, and which is classed as Cenomanian by Nowak, ¶ are not clear. Boule, Lemoine and Thévenin, ** and Kilian and Reboul †† record it from the Upper Senonian, and the last-named authors put it in the genus *Jacobites*, but this is a late Campanian development of the *sparsicosta*-group of *Kossmaticeras*; and the inner whorls of '*Pachydiscus*' *rotalinus* do not suggest affinity with

* "The Fossil Moll. Chalk of England," II, Cephalopoda, iii, 1857, p. 46.

† "Kreide Amm. v. Texas," Geol. und Pal. Abh., N.F., vi, 1904, p. 16, pl. iii, fig. 2.

‡ "Amm. du Crét. Algér.," Mém. Soc. Géol. France, Pal. xvii, No. 42, 1910, p. 37, pl. iii, figs. 1-3.

§ *Loc. cit.*, p. 347.

|| "Les Ammon. d. l. Craie Supér.," Mém. Carte Géol. Détail. d. l. France: II, Paléont., 1894, p. 173, pl. xxii, fig. 5.

¶ *Loc. cit.*, 1913, p. 347.

** "Pal. de Madagascar: III, Céph. Crét. d. Envir. de Diego-Suarez," Ann. de Pal., i, fasc. 4 (1906), pl. vi, fig. 5, and pl. vii, fig. 1.

†† *Loc. cit.*, 1909, pp. 37 and 52.

this stock. On the other hand, '*Pachydiscus*' *rotalinoides*, Yabe,* from the Senonian Toyayo series, which may include any Senonian horizons below the *Parapachydiscus*-beds of the Hokkaido, and also, apparently, not a *Jacobites*, may possibly belong to the genus *Menuites*, described below.

PARAPACHYDISCUS, Hyatt,

was proposed for *A. gollevillensis*, d'Orbigny, which is very close to *Parap. crishna* and to *Parap. egertoni*, Forbes sp., the latter again a very near ally of the European *Parap. neubergicus*, Hauer sp., *Parap. perfidus*, Grossouvre sp., and *Parap. jacquoti*, Seunes sp. Kossmat's Indian "*P. gollevillensis*," † here renamed *Parap. compressus*, n.n., is different from the European type as figured by d'Orbigny and Seunes.‡ A specimen in the British Museum from the Baculite Limestone of Valognes, Manche (No. 50135), represents a new form (*Parap. valognensis*, nov.), with a whorl-thickness of 30 per cent., more closely costate and flatter even than Grossouvre's fig. 9 of plate xxxi. Sharpe's *A. gollevillensis* § represents a more coarsely ornamented type, and the new name *Parap. sharpei* is here proposed for it. A series of Irish specimens in the British Museum includes a further new form, *Parap. hibernicus*, nov. (type No. C 15126), which differs from *Parap. oldhami*, Sharpe sp., in the coarseness of its ornament and from *Parap. sharpei* in having the whorl-section more rounded and the inner whorls continuously costate. Other varieties of *Parap. oldhami* are more finely costate than the type or Grossouvre's form, || e.g. specimen No. C 14830.

A. soma, Forbes, which is not identical with the more inflated *A. ganesa*, Forbes, as Stoliczka and Kossmat had thought, belongs to this group of the genus *Parapachydiscus*, also *P. haldemensis*, Schlüter sp. and, probably, the compressed forms figured by Nowak on plate xl, but the group is not equivalent to Nowak's *egertonianus*-series.

Apart from these compressed forms, which may tend to differentiate the ornamentation on the ventro-lateral edges, *Parapachydiscus* also includes many forms that develop inflated whorls and that are closely connected with the previous group by such forms as *Parapachydiscus ganesa* (Forbes), *P. cricki* (Kossmat), and *P. complexus* (Meek). The numerous species grouping themselves round *Parap. colligatus* (Binkhorst) and *P. deccanensis* (Stoliczka) belong to this division of *Parapachydiscus*, including the three forms

* "Notes on some Cret. Foss. from Anaga, etc.," Science Rep., Tôhoku Imper. Univers., 2nd ser. (Geol.), iv, No. 1, 1915, p. 21, pl. ii, figs. 5 and 6.

† "Unters. S. Ind. Kreideform.," iii, 1898, p. 97 (162), pl. xxi (xv), fig. 1.

‡ "Contrib. Céph. Crét. Supér. France," Mém. Soc. Géol. France, Pal., No. 2, 1891, pl. 5, fig. 1 only.

§ Loc. cit. (iii, 1857), p. 48, pl. xxii, fig. 2.

|| Loc. cit., 1894, pl. xxii, fig. 1.

described by the writer from Zululand, and the *Parapachydiscus* aff. *ootacodensis* (Stoliczka) described below. *P. neubergicus*, var. *stallauensis*, Imkeller,* better renamed *Parapachydiscus stallauensis*, apparently belongs to this second division rather than the first.

Within this comprehensive genus *Parapachydiscus* several lineages, no doubt, could be separated, perhaps by means of the suture-line, but with the data available at present such subdivisions appear to the writer to be artificial, and he would class as *Parapachydiscus*, e.g., both *Pachydiscus kolaturensis* (Stoliczka), Yabe and Shimizu,† and *Parapachydiscus fascicostatum*, Yabe sp.‡

A bituberculate development, derived from the more globose forms of the genus *Parapachydiscus*, leads to *A. menu*, Forbes, with scaphitoid coiling; this development is here separated as

MENUITES, gen. nov.

(genotype: *A. menu*, Forbes, "Report on the Fossil Invertebrata from Southern India, collected by Mr. Kaye and Mr. Cunliffe," Trans. Geol. Soc., ser. ii, vol. vii, 1845, p. 111, pl. x, fig. 1, B.M., Geol. Soc. Coll., No. 10482). *M. sturi*, Redtenbacher sp., and *M. portlocki*, Sharpe sp., well figured by Griepenkerl§ and Wollemann,|| and *M. selbiensis*, Pervinquier sp., belong to this stock.

The original figure of Schlüter's *A. proteus* suggests that *A. auritocostatus*, Schlüter, and '*Pachydiscus*' *ambiguus*, de Grossouvre, represent compressed forms of this genus *Menuites*.

The possibility of certain Scaphitids of the Campanian (*Hoploscaphites*, *Acanthoscaphites*?) having been derived from the present group of Desmoceratids has already been pointed out by the writer. Other late Senonian Scaphitids, however, at present included in these genera, are derived from *Hoplitoplacenticeras* (=group of '*Hoplites*' *vari*).

The Campanian and Maestrichtian genus *Parapachydiscus*, as here understood, is not a direct descendant of the Turonian *Pachydiscus*. It has already been mentioned that in the Lower Senonian there is a group of forms, namely,

* "Die Kreidebild. u. ihre Fauna a. Stallauer Eck u. Enzenauer Kopf bei Tölz," Palaeontographica, 48 (1901), p. 57, pl. iii, fig. 5.

† "Notes on some Cret. Amm. from Japan and California," Science Reports, Tôhoku Imper. Univ., 2nd ser. (Geol.), v, No. 3, 1921, p. 55, pl. viii, fig. 3.

‡ "Notes on some Cret. Amm. from Japan and California," Science Reports, Tôhoku Imper. Univ., 2nd ser. (Geol.), v, No. 3, 1921, p. 57, pl. viii, fig. 5, and pl. ix, figs. 2-5.

§ "Die Verstein. d. Senon. Kreide v. Königslutter, etc.," Pal. Abh., iv, 1889, p. 99, (401), pl. xii, fig. 2.

|| "Fauna d. Lüneburger Kreide," Abh. Preuss. Geol. Landesanst., N.F., Heft 37, 1902, p. 104, pl. vi, figs. 2-3.

NOWAKITES, gen. nov.

(genotype: *N. carezi*, de Grossouvre sp., *loc. cit.*, 1894, p. 190, pl. xxv, fig. 3), attaching itself to such contemporaneous (Coniacian) forms as '*Puzosia le marchandi*, Grossouvre. *Nowakites draschei*, Redtenbacher sp., *N. yokoyamai*, Jimbo sp., *N. canali*, *N. linderi*, Grossouvre sp., and *N. paillettianus*, d'Orbigny sp., probably all belong to this genus, the last apparently entirely different from the Texas *A. flaccidicosta*, Römer, with which Thomas and Peron and Nowak (*loc. cit.*, p. 354) had identified it.

Nowakites savini, Grossouvre sp., represents a lateral offshoot. The forms also bear some resemblance to certain tuberculate *Madrasites*, *Pseudokossmaticeras*, and *Canadoceras*, all of which, however, are of uppermost Senonian age. On the other hand, the Lower Utatur

HOLCODISCOIDES, gen. nov.

(genotype: *A. cliveanus*, Stoliczka, "Foss. Ceph. Cret. Rocks S. India," 1865, p. 157, pl. lxxvii, fig. 3), which also includes *H. moraviatoorensis*, *papillatus*, and *paravati*, Stoliczka sp., and which has wrongly been included in *Kossmaticeras*, is not directly related either to *Nowakites* or to *Madrasites*.

For '*Sonneratia*' *janeti*, Grossouvre, which forms a separate development, allied to *Nowakites*,

PACHYDISCOIDES, gen. nov.

(*loc. cit.*, 1894, p. 145, pl. xxii, fig. 4) is proposed. ? *Pachydiscoides pervinquieri*, n.n. = *P. n. sp. cf. P. janeti*, Pervinquier non Grossouvre,* probably belongs to the same stock.

From the Coniacian stock, here separated as *Nowakites*, forms with increasingly strong ornamentation, like Redtenbacher's *A. isculensis*, result, for which the genus

EUPACHYDISCUS, gen. nov.

(genotype: '*P.*' *isculensis* (Redtenbacher), Grossouvre, pl. xxvi, fig. 1a, b only), is proposed. *Nowakites linderi* (Grossouvre, pl. xxiv, fig. 4), one of the largest species of that genus, already foreshadows the present development; on the other hand, *Eup. levyi* (Grossouvre) and *Eup. grossouvrei* (Kossmat) are transitional to the later and much more abundant *Parapachydiscus*, in which tuberculation seems to begin already in the smooth initial stage. *Eup. jeani* (Grossouvre) is another species, and a Japanese example, studied by the writer, apparently allied to '*Pachydiscus*' *haradai* and *P. teshionensis*, Jimbo, may belong to the same stock.

* "Et. de Pal. Tunis., I, Céph. d. Ter. Second." (1907), p. 174, pl. vii, fig. 11.

The genus

CANADOCERAS, gen. nov.

(genotype: *A. newberryanus*, Meek [Trans. Albany Inst., iv, 1857, p. 47, "Descr. and Illustr. Foss. Vancouver's and Sucia Islands, etc."; Bull. U.S. Geol. and Geogr. Survey Terr., ii, 1876, p. 367, pl. iv, fig. 3], B.M. Geol. Soc. Coll., specimen figured Plate VII, fig. 5, Plate VIII, fig. 4), of the Upper Chico Formation, is allied to the Puzosid development *Kitchinites*, referred to below under *Puzosinae*, i.e. to the group of "*Holcodiscus*" *pondicherryanus*, Kossmat, which persists in the Campanian, together with the true *Kossmaticeras* and its allies. *A. newberryanus*, Gabb non Meek * = "*Pachydiscus*" *henleyensis*, Anderson, is probably a *Parapachydiscus* of the *colligatus*-group, though Anderson,† perhaps wrongly, puts it as of Lower Chico age, and confuses with "*Pachydiscus*" even Horsetown species of *Pleuropachydiscus* ("*Pachydiscus*" *sacramenticus*) and of *Desmoceras* s.s. = *Latidorsella*, Jacob ("*P.*" *merriami*).

A. fraternus, Meek, and *A. suciensis*, Gabb non Meek,‡ belong to *Canadoceras*, as does a closely allied species in the British Museum. The true *A. suciensis*, Meek, or, at least, smooth Vancouver examples in the British Museum, are more doubtfully included here; "*Pachydiscus*" *neevesi*, Whiteaves, is probably a *Grossouvrites*.

Some of the more inflated forms, like *C. multisulcatum*, *binodatum*, and *perplicatum*, Whiteaves sp., though having inner whorls of the *newberryanus*-type, resemble some forms of the other genera here separated; e.g. there may be a tendency to acquire the oblique costation of *Kossmaticeras*, like *K. pachystoma*, Kossmat sp., or of *Kitchinites japonicus*, n.n. = *Desmoceras gaudama*, Yokoyama non Forbes,§ testifying to the Puzosid ancestry of the pachydiscoid '*Kossmaticeras*' here named *Canadoceras*.

The smoother *Canadoceras* of the *suciensis*-group above mentioned resemble a somewhat parallel development, provisionally left in the genus *Parapachydiscus*, and including slowly or quickly coiled (globose) forms, retaining the varices or constrictions of the *Desmoceratid* ancestors; e.g. the Southern Patagonian *P. hauthali*, *P. steinmanni*, and *P. patagonicus*, Pauleke sp., probably also the Japanese '*Pachydiscus*' *naumanni*, Yokoyama. *P. antecursor*, v. Hoepen sp., and *P. umtafunensis* (Crick MS.), Spath, connect this group with the true *Parapachydiscus*, and after a short *hauthali*-stage develop ornamentation foreshadowing that of the *cricki*-group of

* Pal. Calif., i (1864), p. 61, pl. xxvii, figs. 199, 199b, c; pl. xxviii, fig. 199a.

† "Cret. Depos. Pacif. Coast," Proc. Calif. Acad. Sc. (3) Geol., ii, (1902), p. 104 (Wrongly quoted as *A. suciensis*.)

‡ Loc. cit., ii (1869), p. 133, pl. xxi, figs. 11, 11a, b.

§ "Verstein. a. d. Japan. Kreide," Pal., xxxvi (1890), p. 184, pl. xix, fig. 5.

Parapachydiscus. *P. amarus*, Pauleke sp., is a transitional species from *Kitchinites* or *Kossmaticeras*.

The young of '*Pachydiscus*' *conduciensis*, Choffat,* somewhat resembles *P. umtafunensis*, and Choffat's gigantic species may have to be considered as a special offshoot of this group of *Parapachydiscus*. The new genus

LYTODISCOIDES, gen. nov.

(genotype: *Pachydiscus conduciensis*, Choffat, *loc. cit.*, p. 18, pls. ii-v and frontispiece), is proposed for this development. The ornamentation here, though also increasing in strength, is of quite a special type.

As regards the sub-family *Kossmaticeratinae*, the genus *Madrasites*, Kilian and Reboul, is a descendant of the true *Kossmaticeras* (*theobaldianus*-group), and *Gunnarites* and *Grossouvrites* are closely allied genera, but *Seymourites* and *Grahamites* are still doubtful, and at any rate cannot be regarded as subgenera of *Kossmaticeras*. A late Campanian type that, unlike *Madrasites*, does not tend to involution, but leads, via forms of the group of *A. brandti* and *A. düreri*, Redtenbacher, to *Brahmaites*, requires a new name, and

PSEUDOKOSSMATICERAS, gen. nov.

(genotype: *A. pacificus*, Stoliczka, *loc. cit.*, 1865, p. 160, pl. lxxvii, fig. 9), is here proposed. Most of the European "*Kossmaticeras*" belong to this stock.

SUB-FAMILY PUZOSINAE.

Nowak introduced his genus *Parapuzosia* for Ammonites of the '*denisoni*'-type, and he erroneously thought that they could be traced from the Cenomanian to the uppermost Cretaceous. It might, of course, be held that *A. denisonianus*, Stoliczka, is thus the genotype; but this species is not cogenetic with *Parapuzosia daubreei* (Grossouvre), the only species described and figured by Nowak, so that the writer selected this Santonian form as the type of the genus *Parapuzosia*, which also should include *Parap. leptophylla* and *P. (?) icenica*, Sharpe sp., *P. corbarica*, Grossouvre sp., *P. gaudama*, Forbes sp., *P. indopacifica*, Kossmat sp. and *P. stobaei*, Nilsson sp., the latter possibly transitional to *Parapachydiscus*.† The unornamented *A. griffithii*, Sharpe, may be close to the last species, as de Grossouvre thought; for Sharpe's drawing of its suture-line is obviously quite sketchy.

* "Contrib. Connaiss. Géol. Col. Portug. d'Afr.: I, Le Crét. de Conducia," Comm. Serv. Géol. Portug., 1903, p. 18, pls. ii-v and frontispiece.

† This form was considered to be a *Parapachydiscus* in Cret. Ceph. fr. Zululand, 1921, p. 225.

Parapuzosia has the course of the radial line and the constrictions of the strongly projected *subplanulata*-type different from the straight ornamentation of the Campanian

KITCHINITES, gen. nov.

(genotype: *Holcodiscus pondicherryanus*, Kossmat, *loc. cit.*, 1897, p. 40 (147), pl. vi (xvii), fig. 6; British Museum, Geol. Soc. Coll.). This also includes *K. japonicus*, n.n. (= *Desmoceras gaudama*, Yokoyama non Forbes), and a South American form before the writer, near to *K. darwini* (Philippi in Steinmann). The genus is very close to the stock from which also originated *Kossmaticeratinae* (namely, *Kossmaticeras*, *Madrasites*, *Gunnarites*, *Jacobites*, *Pseudokossmaticeras*, *Brahmaites*), but not the isolated *Holcodiscoides*, which is a much earlier offshoot from *Puzosinae*. '*Puzosia*' *ishakawai*, Jimbo, is probably a young *Kitchinites*, hardly distinguishable from the ancestral *Parapuzosia*.

That the genera *Parapuzosia* and *Kitchinites*, which continue the true *Puzosid* type into the Senonian, are not derivatives of the Cenomanian *A. denisonianus*, is clear; for the latter already develops a pachydiscoïd stage, and

PACHYDESMOCERAS, gen. nov.

(type: *A. denisonianus* (Stoliczka), Kossmat, *loc. cit.*, 1898, p. 121 (186), pl. xv, figs. 5a, b), is here proposed for this form. It is probably closely related to the contemporary *Puzosia* of the typical *planulata*-group rather than to the Aptian *Uhligella*, and the Cenomanian *Holcodiscoides* is a close ally. But in the Turonian, true *Puzosids* still persist and give rise to at least two developments, one specialising in size (*Austiniceras*) and the other in crenulation of the periphery (*Tragodesmoceras*). The genus

AUSTINICERAS, gen. nov.

(genotype: *A. austeni*, Sharpe, *loc. cit.*, ii, 1855, p. 28, pl. xii, figs. 1a and b, non 2, B.M., No. C 3382), has inner whorls of the type of *A. dibleyi*, n.n. (= *A. austeni*, Sharpe, p.p. pl. xii, fig. 2 only, holotype, B.M., No. C 13912, Dibley Coll. from *Holaster subglobosus* zone), which is more involute than the type species, and on the outer whorl develops costation of a different type, foreshadowing that of the later *Parapuzosia*. The gigantic *A. mobergi*, *A. poctai*, Grossouvre, and *A. montis-albi*, Låube and Bruder, belong to this genus *Austiniceras*.

TRAGODESMOCERAS, gen. nov.

(genotype: *Desmoceras clypealoides*, Leonhard, "D. Fauna d. Kreidef. i. Oberschles.," Pal., vol. 44 (1897), p. 57, pl. vi, fig. 2), is proposed for a group

of desmoceratid forms sometimes included in *Muniericeras*. This was referred to by the writer on a previous occasion,* and forms the lineage leading from the Turonian *Tr. clypealoides* (Leonhard), *Tr. mülleri* (Grossouvre), and *Tr. hernensis* (Schlüter) to the Lower Senonian *Tr. clypeale* (Schlüter). This lineage is of interest on account of the probable derivation therefrom of keeled forms.

Neither of the genera *Austiniceras* and *Tragodesmoceras* is the direct ancestor of *Parapuzosia*; for in the Turonian forms occur (cf. *Puzosia curvatisulcata*, Chatwin and Withers, and *P. marlowense*, Noble) which are still of the regular *Puzosia* type. The latter was compared to *Desmoceras pyrenaicum*, Grossouvre, which, however, is a *Schlüteria*; the former (*P. curvatisulcata*), with a very complex suture-line (B.M., No. C 12229), may be an *Austiniceras*, and resembles *A. ? gaudemarisii*, Roman and Mazeran sp., but is too fragmentary for exact determination.

Genus PARAPUZOSIA, Nowak.

11. *Parapuzosia haughtoni*, sp. nov.

(Plate VIII, fig. 1.)

? 1921. *Parapuzosia*, sp. nov.? ind., Spath, loc. cit. (Zululand), p. 224, pl. xix, fig. 2; pl. xx, figs. 1, 1a; pl. xxiv, fig. 3.

The large fragment (No. C 19439) on which this description is based, labelled "*Pachydiscus* sp." by Crick, was referred to † as probably a *Parapachydiscus* of the *colligatus-supremus* type on account of its resemblance in smoothness and section of the outer whorl and suture-line to those of the example here described as *Parapachydiscus* aff. *ootacodensis* (Stoliczka). On preparation of the umbilical and dorsal portions of the fragment, however, the ornamentation of the inner whorl was revealed, showing the primary and secondary ribs characteristic of *Parapuzosia daubreei*.

At a whorl-height of 260 mm., the thickness was probably not more than 180 mm. (not 200 mm., as stated in the footnote on p. 229, loc. cit.). The whorl-section thus agrees with that given by the writer for the Zululand form (loc. cit., pl. xx, fig. 1a), and is not so compressed as that of *P. daubreei* as figured by Nowak. ‡ The umbilical wall is higher, and the whorl is thicker at the umbilical border in the South African form; on the other hand, there is no definite umbilical edge, as noted of *P. daubreei* by Grossouvre, but the sides are gradually rounded off into the umbilicus, as illustrated by

* Loc. cit. (Zululand, 1921), p. 237.

† Loc. cit. (Zululand, 1921), p. 229.

‡ "Untersuch. ü. d. Ceph. d. Ob. Kreide i. Polen." : III, Bull. Acad. Sc. Cracovie, Classe Sc. Math. and Nat., ser. B, June 1913, fig. 32, pl. xliii.

Nowak and by the writer for the Zululand example. Since the description of the latter was based only on the photographs and plaster cast of the dorsal area, it is uncertain, of course, whether it belongs to the present species. A comparison of the casts of the dorsal areas of the two forms, however, shows that at any rate the inner whorls, with the typical strongly projected *Parapuzosia* ribbing, are closely similar.

Genus SCHLÜTERIA, Grossouvre em.

12. *Schlüteria simplex*, v. Hoepen sp.

1921. *Desmoceras simplex*, v. Hoepen, *loc. cit.*, p. 19, pl. iii, figs. 11-16, text-fig. 10.

1921. *Schlüteria woodsi*, Spath, Pondoland, p. 45, pl. vii, fig. 1.

The writer does not lay stress on minute differences in the convexity of the sides, proved to be due to sexual dimorphism in the recent *Nautilus*. The dimensions of the two forms, quoted in the synonymy, agree, but whereas Dr. van Hoepen had comparatively small examples, the specimen figured by the writer measured 85 mm. in diameter.

13. *Schlüteria crassa*, v. Hoepen sp.

1906. *Phylloceras* sp., Woods, *loc. cit.*, p. 332, pl. xli, fig. 5.

1921. *Desmoceras crassum*, v. Hoepen, *loc. cit.*, p. 20, pl. iv, figs. 3-4, text-fig. 11.

This form shows more inflation than the last species. It is interesting to note the complexity of its suture-line at a small diameter as compared with that of the Santonian form figured by Grossouvre.*

Genus HAUERICERAS, Grossouvre.

14. *Hauericeras gardeni*, Baily sp.

1921. Spath, Zululand, *loc. cit.*, p. 238, text-fig. A.

1921. v. Hoepen, *loc. cit.*, p. 27, text-fig. 15.

1921. Spath, Pondoland, *loc. cit.*, p. 50 (table).

To the writer's notes on this form in the above-mentioned paper it is only necessary to add that the late G. C. Crick took measurements of 20 out of the 37 examples in the present collection, and the mean of these measurements is :

whorl-height	=	35	per cent. of the diameter.
whorl-thickness	=	19	" " "
umbilicus	=	39	" " "

* *Loc. cit.*, 1894, pl. xxxvii, fig. 9 (as *Desmoceras pyrenaicum*).

The percentages given by v. Hoepen are .34—.17—.40 for an example of 120 mm. diameter. The specimens range from 60 mm. (B.M., No. C 18521) to 145 mm. (C 18516) in diameter, and the relatively thickest form (C 18518) has a narrow umbilicus (dimensions: 130—.34—.215—.40), whereas the thinnest form (C 18517) has a wide umbilicus (dimensions: 138—.30—.16—.46). This, as Mr. Crick observes, is contrary to the general rule given by Grossouvre,* namely, that in the same specific type individuals with a narrow umbilicus show a corresponding compression of the whorls.

The transverse section of an example 106.5 mm. in diameter (B.M., No. C 18520), very close to the type-specimen, allowed of measurements being taken at different stages, and Crick's figures are here appended:

Diameter of shell	106.5 (1)	78.0 (1)	55.0 (1)	38.0 (1)	26.0 (1)	18.5 (1)	12.75 (1)
Height of outer whorl	37.5 (0.352)	29.5 (0.378)	20.75 (0.377)	14.75 (0.388)	10.0 (0.384)	6.5 (0.351)	4.5 (0.352)
Thickness of outer whorl	21.5 (0.201)	16.5 (0.211)	11.5 (0.20)	8.25 (0.218)	5.75 (0.221)	3.5 (0.189)	3.5 (0.274)
Width of umbilicus	41.5 (0.389)	28.25 (0.362)	19.5 (0.354)	13.5 (0.355)	10.0 (0.384)	6.75 (0.364)	4.5 (0.352)

The same transverse section shows that at a diameter of 13 mm. there is no keel, whereas at 18 mm. it first begins to be indicated very feebly. Up to a diameter of 50 mm., the constrictions, also, are biconvex, like those of *H. fayoli*, Grossouvre, or of Forbes's small types of *H. rembda* (= *A. dura*). The course of the constrictions, if it remains biconvex in larger examples of *H. rembda*, as drawn by Stoliczka,† may serve as a distinction between the two species, as, e.g., Pervinquierè‡ had thought; for the larger whorls of *H. gardeni* have semicircular constrictions, sloping forwards towards the umbilical suture as much as the outer half is projected forwards towards the keel. In several examples the apex of this semicircular curve is slightly flattened; in others there may be a small indentation in the semicircle, either near the umbilical edge (No. C 18540) or nearer the periphery (C 18537), suggestive of the original biconvexity, and in the transitional stage the course of the constrictions would be as described for *H. sulcatus* by Kner and Nowak.§

The last example has the periphery of the cast (but not that of the test) still rounded at a diameter of 110 mm., as in Baily's larger specimen (No. 11371, Geol. Soc. Coll.). Another example (C 18522) has lateral grooves

* Loc. cit. (1894), p. 8.

† Loc. cit. (1864), pl. xxxiii, fig. 5.

‡ Loc. cit. (1907), p. 169.

§ Kner, "Verstein. d. Kreidemerg. v. Lemberg," Naturw. Abh., iii (1850), 2, p. 8, pl. i, fig. 3: and Nowak, loc. cit., p. 371, pl. xli, fig. 12, pl. xlv, figs. 44-45.

accompanying the keel (of test only) at 90 mm. diameter, and specimen No. C 18535 has a very strong keel, just beginning to become undercut, as in *H. rembda*, at about 110 mm., set on the far less acute periphery of the cast. Forbes's type of *H. rembda*, on the other hand, shows the acute periphery of the cast, and the peculiar polygonal keel already at 30 mm. diameter. This keel is a more distinct characteristic of *H. rembda* than the biconvex constrictions.

The suture-line of *H. gardeni* (Baily's paratype 11371) differs from that of *H. sulcatum*, as figured by Nowak, in the very regular decrease of the three auxiliary saddles down to the umbilical lobe, a character shown also in some Japanese examples before the writer (Geol. Soc. Coll.). In the latter, however, the periphery is more compressed than in *H. gardeni typus*, or in *H. fayoli*, which latter species they resemble in their constrictions.

H. gardeni, in the present collection, is associated, in the same hand-specimens, with *Mortoniceras*, *Pseudoschloenbachia*, and *Spheniscoceras*.

15. *Hauericeras rembda* (Forbes).

1921. v. Hoepen, *loc. cit.*, p. 28.

1921. Spath, *loc. cit.*, table to p. 50.

This species is not represented in the present collection or apparently in Dr. van Hoepen's material, but was recorded by Griesbach and Woods.*

16. *Hauericeras* ? *sugata* (Forbes).

1921. *Desmoceras compactum*, v. Hoepen, *loc. cit.*, p. 21, pl. iv, figs. 5-7, text-fig. 12.

1921. *Hauericeras* ? *sugata* (Forbes), Spath, Pondoland, p. 46, pl. vi, figs. 3a, b.

Dr. van Hoepen's single immature example hardly justifies the creation of a new species, though it is possible that the Pondoland form may not be of the same date as Forbes's type. The writer assumed (*loc. cit.*, p. 54) that Desmoceratids of the group of *A. sugata* have a fairly wide vertical range. Probably derivatives of several desmoceratid stocks, in the present case *Schlüteria*, successively became carinate and consequently have all been included in this well-known species. There is, however, no satisfactory character to warrant the separation of the immature Pondoland examples from Forbes's species.

* *Loc. cit.* (1906), p. 333.

SUB-FAMILY PACHYDISCINAE.

Genus PARAPACHYDISCUS, Hyatt.

17. *Parapachydiscus* aff. *ootacodensis*, Stoliczka sp.

(Plate VII, fig. 6.)

1921. *Parapachydiscus* sp. ind., Spath, loc. cit. (Pondoland), table to p. 50.

In the description of *Parapachydiscus* sp. n. aff. *colligatus*, Binkhorst sp., from Zululand, the writer referred to two large specimens in the present collection, not described by Crick, that "may belong to *Parapachydiscus* of the *colligatus-supremus* type." One was described as having "an umbilicus of 19 per cent. and a thickness of 45 per cent. of the diameter," the other as showing "at a whorl-height of 260 mm. a thickness of 200 mm." Both were stated to be more compressed than the Zululand example described, and to be intermediate in sectional outline between fig. 30 (*P. colligatus*) and fig. 31 (*P. oldhami*) in Nowak.*

The larger fragment (C 19439) is described above as *Parapuzosia haughtoni*, sp. n., since development of its dorsal area has shown that the resemblance of its smooth outer whorl to the *Parapachydiscus* here described was only superficial. The smaller example (No. C 19438), also labelled "*Pachydiscus* sp." by Crick and not described, has the following dimensions :

at diameter = 150 mm., .50, .45, .19.

At the diameter of 59 mm. the whorl-height = 29 mm., and the thickness = 31 mm. ; on the other hand, where the height of the outer whorl = 150 mm., the thickness is only 125 mm., so that whereas, at first, the whorl-section is round or slightly depressed, with increase of size it becomes compressed. The specimen is still septate at this stage.

P. ootacodensis shows a similar change of proportions, with age, i.e. from the more inflated inner whorls (Stoliczka's fig. 4 of pl. liv) to the more compressed adult figured by Stoliczka on pl. lvi. The ribbing also is similar, though the inner whorls seem more distinctly costate in the Pondoland form, almost as strongly ornamented as those of the much more inflated *P. sp. n. aff. colligatus*, figured by the writer. The present form is thus transitional to the more coarsely ornamented *P. grossouvrei* (Kossmat) = *A. ootacodensis*, Stoliczka, pl. lvii, non cæt., but none of the ribs reaches to the umbilical border. The umbilical edge is perhaps not quite so marked as it is in Kossmat's smooth Indian example.†

The suture-line differs from that of *P. ootacodensis* in having the four

* Loc. cit. (1913), pl. xliii.

† Loc. cit. (1898), fig. 1b, pl. xvi (xxii).

bifid, outer saddles gradually and regularly decreasing to the umbilical border. The four or five inclined simple saddles of the umbilical wall also slope down to the umbilical suture more regularly even than those of *P. tweenianus* (Stoliczka).*

18. *Parapachydiscus simplex*, v. Hoepen sp.

1921. *Pachydiscus simplex*, v. Hoepen, *loc. cit.*, p. 25, pl. v, figs. 3 and 4, text-fig. 14.

This species, belonging to the *ganesa-cricki* group of *Parapachydiscus* (see *ante*, p. 132), is not represented in the present collection.

19. *Parapachydiscus umtafunensis* (Crick MS.), Spath.

(Plate IX, figs. 4a, b.)

1921. Spath, *loc. cit.*, Zululand, p. 229, footnote 5.

1921. „ „ Pondoland, p. 49.

This species, represented by the two examples (Nos. C 19434-5) of dimensions 75-35-36-40 and 72.5-34-35-39, already referred to by the writer, at first sight seems identical with *P. antecursor*, v. Hoepen sp., but has $Th > H$, whereas v. Hoepen's single example is described as having the whorl-thickness equal to or less than the height. The real difference, however, appears to be in the suture-line, that of the present species showing very good agreement with the suture-lines of the South American forms of the group of *P. hauthali*, Paulcke sp., and especially with that of *P. amarus*, Paulcke sp.†

P. tweenianus (Stoliczka), to which the species had been compared by Crick, has a different type of ornamentation.

20. *Parapachydiscus antecursor*, v. Hoepen sp.

1921. *Pachydiscus antecursor*, v. Hoepen, *loc. cit.*, p. 24, pl. v, figs. 1 and 2, text-fig. 13.

This species was compared by its author to a number of pachydiscoid developments, of which only *P. tweenianus* (Stoliczka) is distantly related. In this species, however, the ribbing increases in strength, relatively, on the outer whorls, and the inner whorls are smooth.

* *Loc. cit.* (1865), pl. lv, fig. 1b.

† "Ceph. d. Ob. Kreide Südpatagon.," Ber. Nat. Ges. Freiburg., xv, 1907, p. 62, text-fig. 29.

21. *Parapachydiscus* ? sp. nov.?

1921. Spath, Pondoland, p. 48, pl. vii, figs. 5a, b.

This form, possibly a young *Kitchinites*, is not an immature example of one of the species of *Parapachydiscus* described above, but is too small for accurate identification.

SUB-FAMILY KOSSMATICERATINAE.

Genus MADRASITES, Kilian and Reboul.

22. *Madrasites natalensis* (Crick MS.), Spath.

(Plate V, fig. 3.)

1921. "Cret. Ceph. fr. Zululand," Ann. S. Afr. Mus., xii, pt. vii, No. 16, p. 300.

1921. "Up. Cret. Amm. fr. Pondoland," Ann. Durban Mus., iii, pt. 2, table to p. 50.

This species is based on a well-preserved specimen (No. C 19432) of dimensions 81—34—40—30. It shows the aperture well, like the form of *Madrasites* described below, and was characterised, in the writer's previous papers, as being closely allied to *M. faku*, van Hoepen sp. The latter has a smaller umbilicus and coarser costation therein, and the suture-line is drawn with comparatively simple elements, whereas in the present species it is as ramified as that of *Grossouvrites gemmatus* (Huppé in Steinmann). Mr. Crick's long original description is not now given, since fig. 3 of Plate V will show how close the present species is to *M. faku*, v. Hoepen sp.

23. *Madrasites acuticostatus* (Crick MS.), Spath.

(Plate VIII, fig. 2.)

1921. Spath, Zululand, p. 300.

1921. „ Pondoland, table to p. 50.

This species is represented by a single well-preserved example (No. C 19433) of dimensions 100—37—36—28, and was described at length by Mr. Crick as *Holcodiscus acuticostatus*. It may suffice to quote the following sentence:—

"Compared with the previous species (*H. natalensis*), the present species has a relatively coarser sculpture on the inner, and a finer sculpture on the outer, whorls; it is also a more compressed shell, with a wider umbilicus, and a larger number of tubercles on the umbilical margin."

24. *Madrasites faku*, v. Hoepen sp.

1920. *Holcodiscus faku*, v. Hoepen, *loc. cit.*, p. 144, pl. xxv, figs. 3-4, pl. xxvi, figs. 1-2.

1921. *Madrasites faku* (v. Hoepen), Spath, *loc. cit.*, p. 47, and table to p. 50.

This species is close to the last two, as pointed out by the writer on a previous occasion.

25. *Madrasites africanus*, v. Hoepen sp.

1920. *Holcodiscus africanus*, v. Hoepen, *loc. cit.*, p. 146, pl. xxvi, figs. 3-5.

1921. " " " " *loc. cit.*, p. 23.

1921. *Madrasites africanus* (v. Hoepen), Spath, *loc. cit.*, p. 48, and table to p. 50.

This was compared by the writer to *M. buddhaicus* (Kossmat), from which it differs merely in proportions.

26. *Madrasites aff. africanus*, v. Hoepen sp.

1921. *Holcodiscus africanus*?, v. Hoepen, *loc. cit.*, p. 23.

A specimen of *Madrasites* was described by Dr. van Hoepen as being relatively thicker than *M. africanus* and showing other differences.

27. *Madrasites* sp. ind.

1906. *Holcodiscus* sp., Woods, *loc. cit.*, p. 336, pl. xlii, fig. 2.

1921. *Madrasites* sp. ind. (Woods), Spath, Pondoland, p. 48, and table to p. 50.

This form has a smaller umbilicus and finer ornament than *M. africanus*. It was compared to *Jacobites anderssoni* by Kilian and Reboul,* and shows, indeed, close resemblance in the inner whorls to the form figured by these authors on pl. vii, fig. 2, if one may judge by Professor Kilian's casts of his Antarctic specimens in the British Museum. Nothing like the adult *Jacobites*, however, seems to have been found in Pondoland, so that Mr. Woods's form is here considered to be nearer to the typical *Madrasites madrasinus* (Stol.).

28. *Madrasites similis*, Spath.

1921. Spath, Pondoland, p. 48, pl. vi, fig. 1.

This form was described as standing in the same relationship to (the tuberculate) *M. faku* as *Kossmaticeras sparsicostatum* (Kossmat) does to (the costate) *K. theobaldianum* (Stol.).

* "Céph. Néocrét., etc.," *Wiss. Ergeb. Schwed. S. Pol. Exp.*, iii, 6, 1909, pp. 62-3.

INCERTAE SEDIS.

Genus *Hoploscaphites*, Nowak.

At least four species of this genus have been described, but the examples are mostly too fragmentary or too immature to allow of definite specific identifications.

29. *Hoploscaphites* sp. (cf. *similaris*, Stoliczka ?).

1906. *Scaphites* sp., Woods, *loc. cit.*, p. 343, pl. xlv, figs. 8a-c.

30. *Hoploscaphites* sp. (cf. *pavana*, Forbes ?).

1921. *Scaphites cunliffei*. v. Hoepen (non Forbes), *loc. cit.*, p. 28, pl. v, figs. 5-7, text-fig. 16.

? 1921. *Hoploscaphites* sp. juv., Spath, Pondoland, p. 49.

31. *Hoploscaphites* sp. nov. ?

1921. *Scaphites* sp., v. Hoepen, *loc. cit.*, p. 29, pl. v, figs. 8, 9.

32. *Hoploscaphites* sp. ind.

1921. *Scaphites* sp., v. Hoepen, *loc. cit.*, p. 30.

FAMILY PRIONOTROPIDAE.

Genus MORTONICERAS, Meek.

33. *Mortoniceras soutoni*, Baily sp.

(Plate VII, fig. 4.)

1921. Spath, *loc. cit.* (Zululand), p. 234, pl. xx, fig. 4.

1921. v. Hoepen, *loc. cit.*, p. 38, pls. x, xi, text-figs. 19-22.

1921. Spath, *loc. cit.* (Pondoland), table to p. 50.

Of the twelve specimens referable to the group of *M. soutoni*, five are too fragmentary to be definitely identified with any of the types mentioned below, but the remaining examples show great variability, as do the specimens described by Dr. van Hoepen. The specimen (No. C 19441) referred to as close to Baily's type, the suture-line of which was figured by the writer,* seems to be the most typical, though it has a considerable number of bifurcating ribs. A fragment (C 19469) is probably also close to the type, whereas

* *Loc. cit.* (Zululand, 1921), pl. xx, fig. 4.

specimen C 19461 is nearer to the (at a corresponding size) slightly less closely costate and more evolute example figured by Woods. In this last specimen (C 19461) the costation is regular, single, and relatively closer on the inner whorls; in the first (C 19441) the beginning is more distantly costate, and closeness of the ribbing and bifurcation set in only at a later stage.

A still more closely costate type than C 19461 is C 19442, but here the sharp umbilical edge of the holotype is lost on the outer whorls. The suture-line of this example is figured on Plate VII, fig. 4. C 19454 has a more distantly costate beginning even than C 19441, but otherwise is a characteristic *M. soutoni*. Specimen C 19451, on the other hand, in which the distant costation of the inner whorls persists to a comparatively late stage, and which also has a more inflated outer whorl, is transitional to *M. aff. umkwel-anense*, Crick, described by the writer.* Still another and more evolute form (C 19460) has the costation of the outer whorl more distinctly reclined than the holotype or other examples. Finally, No. C 19447, similar in the inner whorls to the example figured by Woods, has costation simple on the outer whorl and more distant than the ribbing of any other specimen.

The Zululand form described by the writer as *M. aff. soutoni* is not represented in the present collection.

34. *Mortoniceras stangeri*, Bailly sp.

(Plate IX, fig. 2.)

1921. Spath, *loc. cit.* (Zululand), p. 297.

1921. " " (Pondoland), table to p. 50.

Thirty-one examples, including a few impressions and plaster-casts thereof, are referable to this species and its varieties, the great majority of the examples being close to the specimen figured by Woods and to Bailly's holotype (Geol. Soc. Coll., 11366) and two paratypes (11367 and 68). They include specimens C 19440 and C 19443, the suture-lines of which were figured in text-figs. 1c, 1b of the writer's Zululand paper (p. 297), and C 19459, of which a sectional outline of the inner whorls and the internal suture-line were given (*loc. cit.*, pl. xxiii, figs. 3a, b).

The dimensions of Bailly's types are :—

	Holotype (11366).	Paratype (11367).	Paratype (11368).
Diameter . . .	320 mm.	101 mm.	115 mm.
Height of outer whorl .	26 per cent.	31 per cent.	27 per cent.
Thickness of outer whorl	19 "	31 "	27 "
Umbilicus . . .	56 "	47 "	51 "

* *Loc. cit.* (Zululand, 1921), p. 234, text-fig. D 2, p. 297.

The outer whorl flattens out in all the large examples, but the two quadrate-whorled paratypes do not quite agree in ornamentation either with the holotype or with each other. No. 11367 is transitional to the var. *sparsicosta*, described below, and has a very indistinct median lateral tubercle; in 11368 this tubercle is as pronounced as in the example figured by Woods.

35. *Mortoniceras stangeri* (Baily), var. *sparsicosta*, nov.

(Plate V, fig. 1.)

In some of the examples of *M. stangeri*, described above, the inner whorls are less closely costate than in the type. These are transitional to the present variety, which is characterised by the comparatively coarse and distant tuberculation of the inner whorls, and the depression until a fairly late stage of the whorl-section. Baily's paratype 11368A, the internal suture-line of which was figured on pl. xxiii, fig. 3c, of the writer's Zululand paper, also specimen No. C 19444 (text-fig. 1a, p. 297, *loc. cit.*), belong to this variety. The lateral view of the latter specimen is represented in fig. 1 of Plate V, and has dimensions: 295—27—25—53.

Crick included specimen C 19444 in what he listed as an "intermediate group between *M. stangeri* and *M. soutoni*," but none of the examples in his list has any resemblance to *M. soutoni*. Moreover, there is no description of any of these *Mortoniceras*, and even the most typical example of *M. soutoni* was erroneously listed as *M. stangeri*.

36. *Mortoniceras stangeri* (Baily), var. *densicosta*, nov.

(Plate V, fig. 2.)

This is a more finely costate variety, typically represented by specimen C 19456, here figured, of the following dimensions: 125—28—25—52. The inner whorls of this specimen also seem more compressed, though slightly crushed. Some transitional examples (C 19450, C 19450A, C 19462) connect this variety with the typical *M. stangeri*, just as this again is connected by a series of gradations with the var. *sparsicosta*. The outer whorls of the three forms here described are very similar, and tend to weaken the tuberculation of the costae.

The occurrence of distantly and closely ribbed varieties is of interest in connection with a recent paper by Professor Salfeld.* In the varieties of *M. stangeri*, however, there is no correlated change in whorl-section, and the var. *densicosta* is not so common as the other forms, being typically

* "Bemerkungen zu v. Bubnoff, etc.," Zeitschr. f. indukt. Abstamm. und Vererb. Lehre, 1921.

represented by only one example. The writer is of opinion that the common occurrence of these types of variation in Ammonites (not mutations, since, apparently, they are contemporaneous) may be taken to indicate a form of "dimorphism," or rather of "polymorphism." The "polymorphism," however, necessitates agreement in the other characters, which would have to be ascertained to exist in a larger number of specimens than are available in the present instance. Moreover, it is difficult to stipulate what would be agreement in, *e.g.*, the suture-lines; and since the change of a species-group into another and later one occurs by means of adaptive radiation, graphically represented by fans or a multitude of more or less radiating lines rather than by a single line in the customary genealogical tree, opinions would differ greatly as to the "agreement" in a given species-group. The fact that the adult whorls of the various forms here discussed become similar, but not "catagenetic," shows that this "polymorphism" is a phenomenon quite different from the simplification of the ornament on the outer whorls of many Ammonites, which may tend to perfection of adaptation in, *e.g.*, *Ozynoticeras*, and which often, like the approximation of the last few septa, marks only the slackening of growth on reaching maturity, but which, also, may be simply correlated with the overlap of the mantle in the mature stage.

Genus PSEUDOSCHLOENBACHIA, Spath.

37. *Pseudoschloenbachia umbulazi*, Baily sp.

(Plate VI, fig. 5.)

1921. *Pseudoschloenbachia umbulazi* (Baily), Spath, Zululand, p. 240, pl. xx, fig. 2, text-fig. B, p. 241.

1921. *Schloenbachia umbulazi* (Baily), v. Hoepen, *loc. cit.*, p. 35, pl. viii, figs. 6-9, pl. ix, figs. 1 and 2.

1921. *Pseudoschloenbachia umbulazi* (Baily), Spath, Pondoland, table to p. 50.

The measurements of typical examples agree with those given by Dr. van Hoepen, *e.g.* No. C 19427 has dimensions 50—52—28—14. The inner whorls of this example were figured by the writer (*loc. cit.*, text-fig. B1, p. 241). They show that at a diameter of 32 mm. the thickness = 30 per cent., and the umbilicus = 18 per cent., so that the whorls become relatively thinner with age, whereas the umbilicus narrows. At a diameter of 21 mm. the thickness has increased to 33 per cent. In the var. *acuta*, at the same diameter, the whorl-thickness is only 26 per cent.

The writer has pointed out that these Pondoland examples represent more strongly ornamented varieties, with increasing tuberculation round

the umbilicus. This is partly due to the larger size of the Pondoland examples; for at a size corresponding with that of the geno-holotype, figured on pl. xx, fig. 2, of the Zululand paper, the umbilical tuberculation of the present specimens is pushed back to only a very slightly earlier stage. The term variety, thus, is hardly applicable to these forms. In example No. C 19426, however, here figured (Plate VI, fig. 5), of dimensions 46—52—29—13, the umbilical tubercle is decidedly more distinct than in the neotype, which seems to agree in this respect with Baily's lost holotype. Dr. van Hoepen's figs. 1 and 2 of pl. ix represent a similar form. This was again selected as neotype by Dr. van Hoepen, but the writer had fixed the geno-neotype just previously. This form is transitional from the true *P. umbulazi* to the species described below as *P. pseudofournieri*, and thence to *P. papillata*.

The new Egyptian species of *Pseudoschloenbachia*, mentioned by the writer on previous occasions and figured on Plate V, fig. 4, as *P. humei*, nov.,* is distinguished from *P. umbulazi* by more distinct costation and tuberculation, especially at the ventro-lateral edges. This Egyptian specimen is preserved as a chalcedonic cast, resembling the mode of preservation of a cast in flint of a new *Sphenodiscus*, allied to *S. acutodorsatus*, Noetling, from beds of the same age near Jerusalem (B.M. C 22136).

Specimens No. C 19436-7 are associated with *Hauericeras gardeni* and *Mortonicerias stangeri*, in addition to other mollusca, in the same blocks.

38. *Pseudoschloenbachia pseudofournieri*, nov.

(Plate VI, fig. 3.)

This species is based on example C 19425 of dimensions 57—48—27—19, referred to previously (Zululand, p. 242) as being slightly constricted and transitional in ornamentation, from *P. umbulazi* to *P. papillata*. It differs from the former in the largeness of its umbilicus and the presence of the constrictions, in addition to the greater strength of its ornamentation, with fewer, but prominent, umbilical tubercles. *P. papillata* represents a still more coarsely ornamented type, with a yet wider umbilicus. Ornamentation and constrictions of the present species recall Grossouvre's '*Schloenbachia*' *fournieri*,† probably belonging to the genus *Gauthiericeras*; but the acute periphery of *Pseudoschloenbachia* and the numerous

* Blanckenhorn's label, in German, attached to this specimen, reads as follows: "*Schloenbachia* n. sp. ind. aff. *varians*, yet not two, but three or four auxiliary lobes, i.e. three auxiliary lateral lobes and one umbilical lobe. The first lateral lobe unusually broad-stemmed, deeply bipartite. Cenoman?"

† *Loc. cit.* (1894), p. 112, pl. xxxv, fig. 1.

elements of its suture-line are important distinctions from the earlier stock.

P. humei, nov. (Plate V, fig. 4), has more numerous but less prominent inner tubercles, and more distinct and fewer outer nodes.

39. *Pseudoschloenbachia papillata* (Crick MS.), Spath.

(Plate IX, figs. 1a, b.)

1921. *Pseudoschloenbachia papillata* (Crick MS.), Spath, Zululand, pp. 240 and 242.

1921. *Schloenbachia umbulazi*, var. *spinifera*, v. Hoepen, *loc. cit.*, p. 37, pl. ix, figs. 3-7.

1921. *Pseudoschloenbachia papillata* (Crick MS.), Spath, Pondoland, p. 43, pl. vi, figs. 2a, b.

This form is sufficiently distinct from *P. umbulazi* to be accorded specific rank.

40. *Pseudoschloenbachia griesbachi* (Crick MS.), Spath.

(Plate VII, fig. 1; Plate VI, fig. 4.)

1921. *Pseudoschloenbachia griesbachi* (Crick MS.), Spath, Zululand, p. 240, text-fig. B8 on p. 241, p. 312.

1921. *Schloenbachia umbulazi*, var. *griesbachi*, v. Hoepen, *loc. cit.*, p. 35, pl. vii, figs. 3 and 4, pl. viii, figs. 1-5, text-figs. 17-18.

1921. *Pseudoschloenbachia griesbachi* (Crick MS.), Spath, Pondoland, table to p. 50.

Crick's long description of this species is omitted. The dimensions of the holotype are: 103—51—25—14; those of the paratype: 33—52—26—13. The suture-line of the holotype was figured by the writer on a previous occasion.

INCERTAE SEDIS.

41. Gen. nov. (*Muniericeras* ?) *cricki*, Spath.

1921. *Loc. cit.*, Pondoland, p. 44, pl. vii, figs. 4a, b.

It is interesting to note that Dr. van Hoepen remarked the resemblance of young examples of *Pseudoschloenbachia papillata* (his *Schloenbachia umbulazi*, var. *spinifera*) to Grossouvre's *Muniericeras lapparenti*. The tuberculate periphery of the present form, however, separates it from the genus *Pseudoschloenbachia*, and it may be only a heterochronous homœomorph of the Lower Senonian *Muniericeras*.

Genus EULOPHOCERAS, Hyatt.

42. *Eulophoceras natalense*, Hyatt.

1921. Spath, Pondoland, table to p. 50.

As will be mentioned in the description of *Spheniscoceras*, Hyatt's form may be only one and an uncommon type of the development separated from *Eulophoceras* by Crick and again by Dr. van Hoepen on account of minute differences in what appears to be a very variable suture-line.

Genus SPHENISCOCERAS (Crick MS.), Spath.

1921. Spath, *loc. cit.* (Zululand), p. 242, text-fig. C 1, p. 243.

Genotype: *S. africanum* (Crick MS.), Spath, *ibid.*, p. 243, fig. C 1a (Plate VI, fig. 1).

In the original diagnosis this group is described as "intermediate between *Placenticeras* and *Sphenodiscus*, Meek," and after giving the characteristics of these two genera Crick continues:

"In the present genus the shell is discoidal, lenticular, with a very small or a closed umbilicus, the sides with obscure radiating ridges; the periphery is acute and usually pinched in a little on either side. The lobes and saddles of the suture-line are rather numerous, but not so many as in *Placenticeras* and *Sphenodiscus*. In the suture-line the saddles are feebly incised and have not entire margins as in *Sphenodiscus*; the external lobe is wide and very deep; the external saddle is deeply divided by a secondary lobe.

"This genus is represented in the present collection by three [four] examples and a fragment. The examples, which range from 102 to more than 157 mm. in diameter, appear to belong to four different species."

The suture-lines of Crick's three species were figured by the writer on a previous occasion; that of *Spheniscoceras* cf. *amapondense*, here reproduced, is of interest in that it has the external saddle less indented than the other "species," and the ventral lobe is very shallow.

The absence of any reference to *Eulophoceras*, Hyatt, to which genus Crick refers the specimens in 1906 (see Woods, *loc. cit.*, p. 337) is the more remarkable as the four "species" of Crick are very close to *Eulophoceras natalense*, Hyatt, and it might be held that the development of what may be a thinner keel, and the slight differences in suture-line and ornamentation, are not sufficient to justify the creation of even different species.

The ornamentation of the earlier whorls of *Sph. minor* has great resemblance to that of *Diaziceras*; but since the early whorls of *D. tissotiaeforme* are compressed (*loc. cit.*, Zululand, pl. xix, fig. 1c), *Spheniscoceras* cannot be

a direct descendant of *Diaziceras*, but must be looked upon as a more or less parallel development therewith of the normally lobed *Pseudoschloenbachia* and the form described as gen. nov. (*Muniericeras*?) *cricki*, Spath. *Eulophoceras*, if distinct at all, is a closely similar development. From Hyatt's description, however, it appears that the ornamentation of his somewhat imperfect holotype of *Eulophoceras* is not strongest at the umbilical and the ventro-lateral shoulders, as in *Diaziceras* and in the early whorls of *Spheniscoceras*.

The fact that Dr. van Hoepen, who again created a new genus for the group here discussed, did not record the true *Eulophoceras natalense*, confirms the writer's opinion that the separation of *Spheniscoceras* from *Eulophoceras* is not well founded, and Hyatt's type, which is not well preserved, may represent only an extreme variation.

Lenticeras? *jullieni*, Pervinquière, which was included in the present stock by Dr. van Hoepen, is here considered to belong to the Coniacian family *Tissotidae*. It was selected as type of *Prelybicoceras*, Douvillé,* already in 1912.

The internal suture-line of *Sph. tenue* is here figured for comparison with that of *Sphenodiscus*, in which genus more pronounced reduction has resulted in monophylloid saddles. This character induced Salfeld † to consider the genus *Sphenodiscus* and the families *Placenticeratidae*, *Coilopoceratidae*, and *Engonoceratidae* to belong to the super-family *Phylloceratida*.

43. *Spheniscoceras africanum* (Crick MS.), Spath.

(Plate VI, fig. 1.)

1921. *Spheniscoceras africanum* (Crick MS.), Spath, *loc. cit.* (Zululand), p. 242, fig. C1a, p. 243.

1921. ? *Pelecodiscus capensis*, v. Hoepen, *loc. cit.*, p. 32, pl. v, fig. 11.

1921. *Spheniscoceras africanum* (Crick MS.), Spath, Pondoland, table to p. 50.

The holotype of this species (C 19421) of dimensions 157—59—28—03, was described in detail by Mr. Crick, but there is now no need to give the original diagnosis. Dr. van Hoepen's small form is doubtfully included here. Its suture-line, however, shows inclination towards the umbilicus, like the suture-lines of the other species mentioned below.

* "Evolut. and Classif. d. Pulchell.," Bull. Soc. Géol. France (4), xi, 1911, fasc. 4-5 (1912), p. 315.

† "Üb. d. Ausgestalt. d. Lob. Lin. b. Jura und Kreide Amm.," Nachr. K. Ges. Wiss. Göttingen, Math.-Phys. Kl., 1919, pp. 8 and 9 (of separate copy).

44. *Spheniscoceras tenue* (Crick MS.), Spath.

(Plate VIII, fig. 3; Plate VII, fig. 3.)

1921. Spath, *loc. cit.* (Zululand), p. 242, text-fig. C 1c, p. 243.

1921. " " (Pondoland), table to p. 50.

This species is represented in the collection by one example, almost completely septate, of the following dimensions: 122.5—63—23—00. Crick described this species in detail, but it is characterised in the one sentence:—

"Besides the differences in the suture-line, this species is easily distinguished both from *Spheniscoceras africanum* and *Sph. minor* by its greater compression and much more feeble ornaments."

45. *Spheniscoceras minor* (Crick MS.), Spath.

(Plate VI, fig. 2.)

1921. Spath, *loc. cit.* (Zululand), p. 242, text-fig. C 1b, p. 243.

1921. " " (Pondoland), table to p. 50.

This species was based on specimen C 19422, the dimensions of which are: 102—64—27—00. These dimensions were taken at the beginning of the body-chamber. A portion of this is preserved, but is very imperfect. Of Crick's description only the following need be quoted: "At first sight this appears to be an immature specimen of *Sph. africanum*, but the form of the suture-line does not justify that conclusion. The character of the umbilicus [perfectly closed], as well as the fewness and prominence of the undulations on the inner half of the lateral area, serves also to separate this species from *Sph. africanum*. The ornaments of the test and the form of the suture-line also distinguish this species from *Sph. tenue*."

A second example, not noticed by Crick, is enclosed in a block of matrix attached to one of the *Mortonicerases*, referred to under *M. soutoni*, and considered to be transitional to *M. aff. umkuelanense* (C 19451). The strong ornamentation is even more pronounced in this second specimen.

46. *Spheniscoceras amapondense*, v. Hoepen sp.

(Plate VII, fig. 2.)

1921. *Peleciodiscus amapondensis*, v. Hoepen, *loc. cit.*, p. 33, pl. vii, figs. 1 and 2.

A fragment (No. C 19424) in the collection, described by Mr. Crick as '*Spheniscoceras*, sp. ind.,' agrees with the smooth outer whorl of the type-

species, *S. africanum*, but its suture-line differs from those of the known "species" of this genus, notably in the external saddle. The suture-line of *S. amapondense* is probably nearer than any other to that of the present fragment, but the half of the suture-line of *S. africanum*, opposite to that figured, is also similar, so that by splitting one of these specimens in two still further "species" could be established.

47. *Spheniscoceras umzambiense*, v. Hoepen sp.

1921. *Pelecodiscus umzambiensis*, v. Hoepen, *loc. cit.*, p. 30, pl. v, fig. 10, pl. vi, fig. 1.

The suture-line of this form differs slightly from those of the other "species" here recorded.

FAMILY NOSTOCERATIDAE.

Genus BOSTRYCHOCERAS, Hyatt.

48. *Bostrychoceras* ? *amapondense*, v. Hoepen sp.

1921. *Bostrychoceras* ? sp. nov., Spath, Zululand, p. 252.

1921. *Heteroceras amapondense*, v. Hoepen, *loc. cit.*, p. 17, pl. iv, figs. 1 and 2.

1921. *Bostrychoceras* ? sp. (Woods), Spath, Pondoland, *loc. cit.*, table to p. 50 (Nos. 37, 38).

1921. *Diplomoceras* ? sp. (Woods), Spath, *ibid.*, No. 40.

Genus DIPLOMOCERAS, Hyatt.

49. *Diplomoceras* ? *indicum* (Forbes).

1906. *Hamites* (*Anisoceras*) *indicus*, Forbes; Woods, *loc. cit.*, p. 340, pl. xlv, figs. 2a, b.

1921. *Diplomoceras* ? *indicum* (Forbes), Spath, *loc. cit.*, table to p. 50 (No. 39).

Genus OXYBELOCERAS, Hyatt.

50. *Oxybeloceras amapondense*, v. Hoepen sp.

1921. "*Hamites*" cf. *quadrinodosus*, Jimbo; Spath, Zululand, p. 255.

1921. *Oxybeloceras* ? sp., cf. *interruptum*, Schlüter sp., Spath, *ibid.*

1921. *Hamites amapondensis*, v. Hoepen, *loc. cit.*, p. 15, pl. iii, figs. 5, 6, text-fig. 9.

1921. *Oxybeloceras* ? cf. *quadrinodosum*, Jimbo sp.; Spath, Pondoland, p. 50, pl. vii, figs. 2a, b.

Genus *NEOCRIOCERAS*, Spath.51. *Neocrioceras* cf. *spinigerum*, Jimbo sp.

1921. Spath, Pondoland, pp. 51-2, pl. vii, figs. 6a c.

FAMILY BACULITIDAE.

Genus *BACULITES*, Lamarck.52. *Baculites capensis*, Woods.

1921. Spath, Pondoland, table to p. 50.

This species is represented by one example (No. C 19420) of a length of 45 mm.

53. *Baculites sulcatus*, Baily.1921. v. Hoepen, *loc. cit.*, p. 18, pl. iii, figs. 7, 8.

1921. Spath, Pondoland, table to p. 50.

54. *Baculites bailyi*, Woods.1921. v. Hoepen, *loc. cit.*, p. 18, pl. iii, figs. 9, 10.

1921. Spath, Pondoland, table to p. 50.

EXPLANATION OF PLATES.

PLATE V.

FIG.

1. *Mortoniceras stangeri* (Baily), var. *sparnicosta*, nov. Umzamba Beds, Pondoland. B.M., No. C 19444. (Suture-line figured in Spath, *loc. cit.* (Zululand), p. 297, text-fig. D 1a.) Reduced $\frac{1}{2}$. (P. 138.)
2. *Mortoniceras stangeri* (Baily), var. *densicosta*, nov. Umzamba Beds, Pondoland. B.M., No. C 19456. Reduced $\frac{1}{2}$. (P. 138.)
3. *Madrasites natalensis* (Crick MS.), Spath. Umzamba Beds, Pondoland. B.M., No. C 19432. (P. 134.)
4. *Pseudoschloenbachia humei*, nov. Near Bir Mellaha, Egypt. No. I, 2288. 4a = sectional outline. (Pp. 140, 141.)

PLATE VI.

1. *Spheniscoceras africanum* (Crick MS.), Spath. Geno-holotype. B.M., No. C 19421. Reduced $\frac{1}{2}$. (P. 143.)
- 2a, b. *Spheniscoceras minor* (Crick MS.), Spath. B.M., No. C 19422. Lateral and sectional views. (P. 144.)
- 3a, b. *Pseudoschloenbachia pseudofournieri*, nov. B.M., No. C 19425. Lateral view and sectional outline. (P. 140.)
4. *Pseudoschloenbachia griesbachi* (Crick MS.), Spath. Paratype, B.M., No. C 19429. (P. 141.)

FIG.

5. *Pseudoschloenbachia umbulazi* (Baily), var., with more pronounced umbilical tubercles. B.M., No. C 19426. (P. 139.)
 6. *Tetragonites superstes*, v. Hoepen. With mouth-border. B.M., No. C 19416. (P. 119.)
- (All the specimens on this plate are from the Umzamba Beds of Pondoland.)

PLATE VII.

- 1a, b. *Pseudoschloenbachia griesbachi* (Crick MS.), Spath. Holotype, B.M., No. C 19428. Side view and sectional outline. (P. 141.)
2. *Spheniscoceras* cf. *amapondense*, v. Hoepen sp. Portion of suture-line, with external and first lateral saddles. S=siphonal line. B.M., No. C 19424. (P. 144.)
3. *Spheniscoceras tenue* (Crick MS.), Spath. Internal suture-line, enlarged and diagrammatic, at diameter=115 mm. A=antisiphonal line. B.M., No. C 19423. (P. 144.) See Plate VIII, fig. 3.
4. *Mortoniceras* aff. *soutoni* (Baily). Suture-line of, B.M., No. C 19442, last (?) septum, at about 250 mm. diameter. S=siphonal line. (P. 136.)
(Specimens 1-4 from the Umzamba Beds of Pondoland.)
5. *Canadoceras neuberryanum* (Meek). Geno-holotype, British Museum (Geol. Soc. Coll.), Upper Senonian of Vancouver Island. Reduced $\frac{1}{2}$. (P. 125.) See Plate VIII, fig. 4.
6. *Parapachydiscus* aff. *ootacodensis*, Stoliczka sp. Outline-section of inner whorls of specimen C 19438 from the Umzamba Beds of Pondoland. (P. 132.)

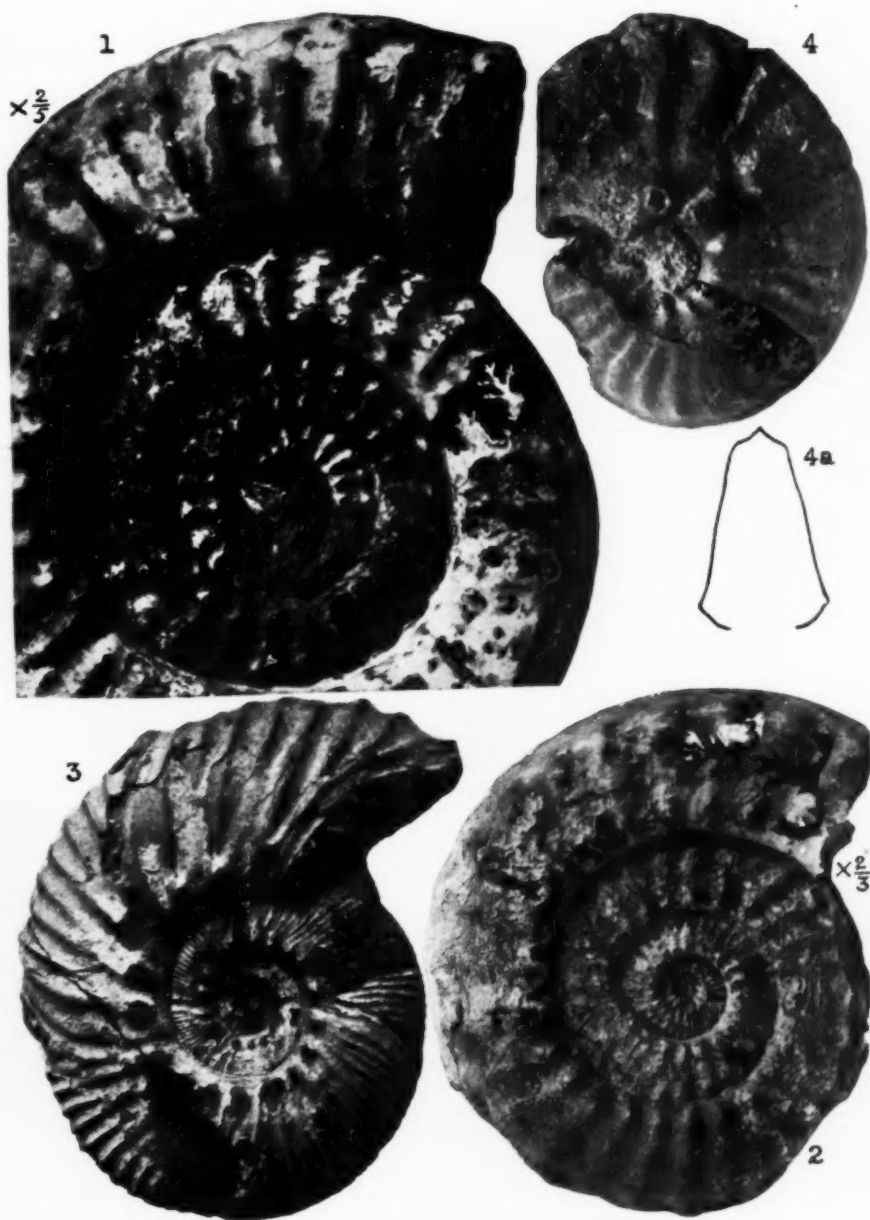
PLATE VIII.

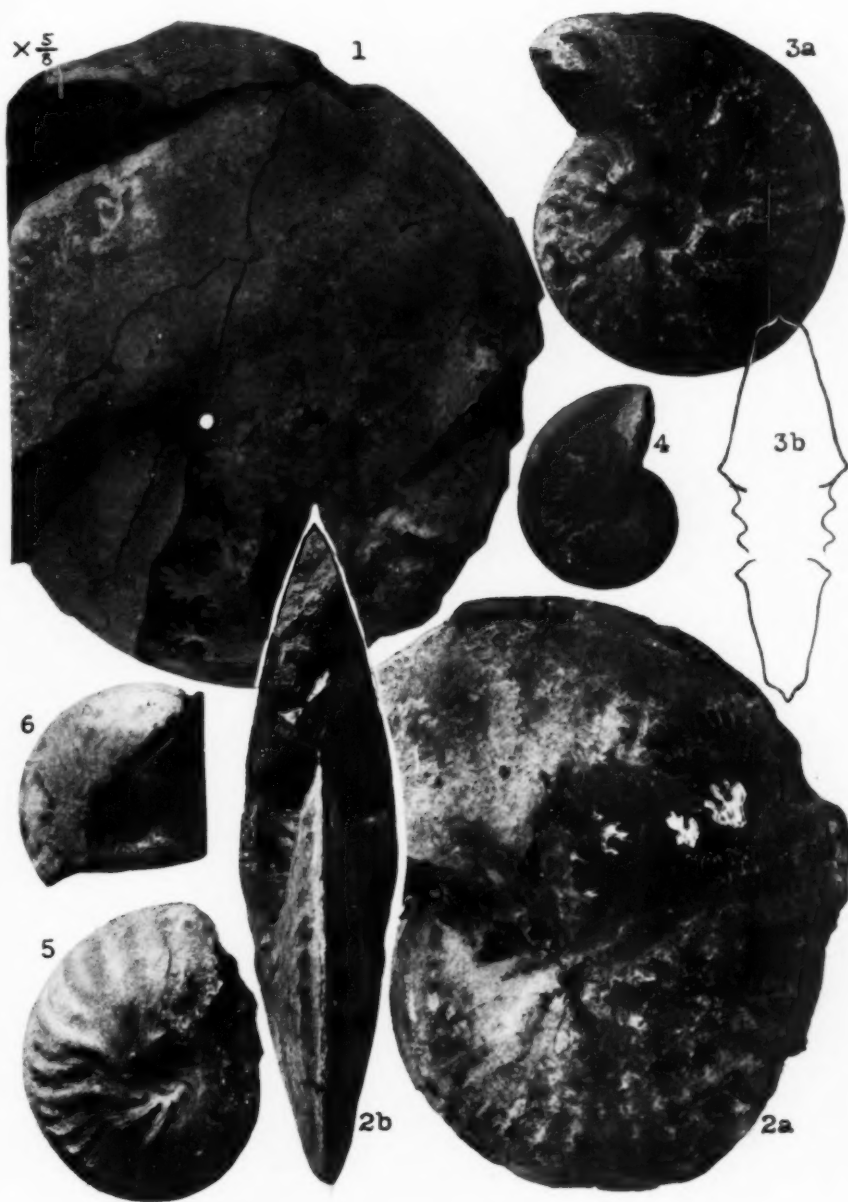
1. *Parapuzosia haughtoni*, sp. nov. Lateral view of portion of cast of dorsal impression of specimen, B.M., No. C 19439, to show ornamentation of (missing) inner whorl. Reduced $\frac{1}{2}$. (P. 128.)
2. *Madrasites acuticostatus* (Crick MS.), Spath. B.M., No. C 19433. (P. 134.)
3. *Spheniscoceras tenue* (Crick MS.), Spath. B.M., No. C 19423. (P. 144.) See Plate VII, fig. 3.
(Specimens 1-3 from the Umzamba Beds of Pondoland.)
4. *Canadoceras neuberryanum* (Meek). Reduced $\frac{1}{2}$. Peripheral view of specimen figured on Plate VII, fig. 5. (P. 125.)

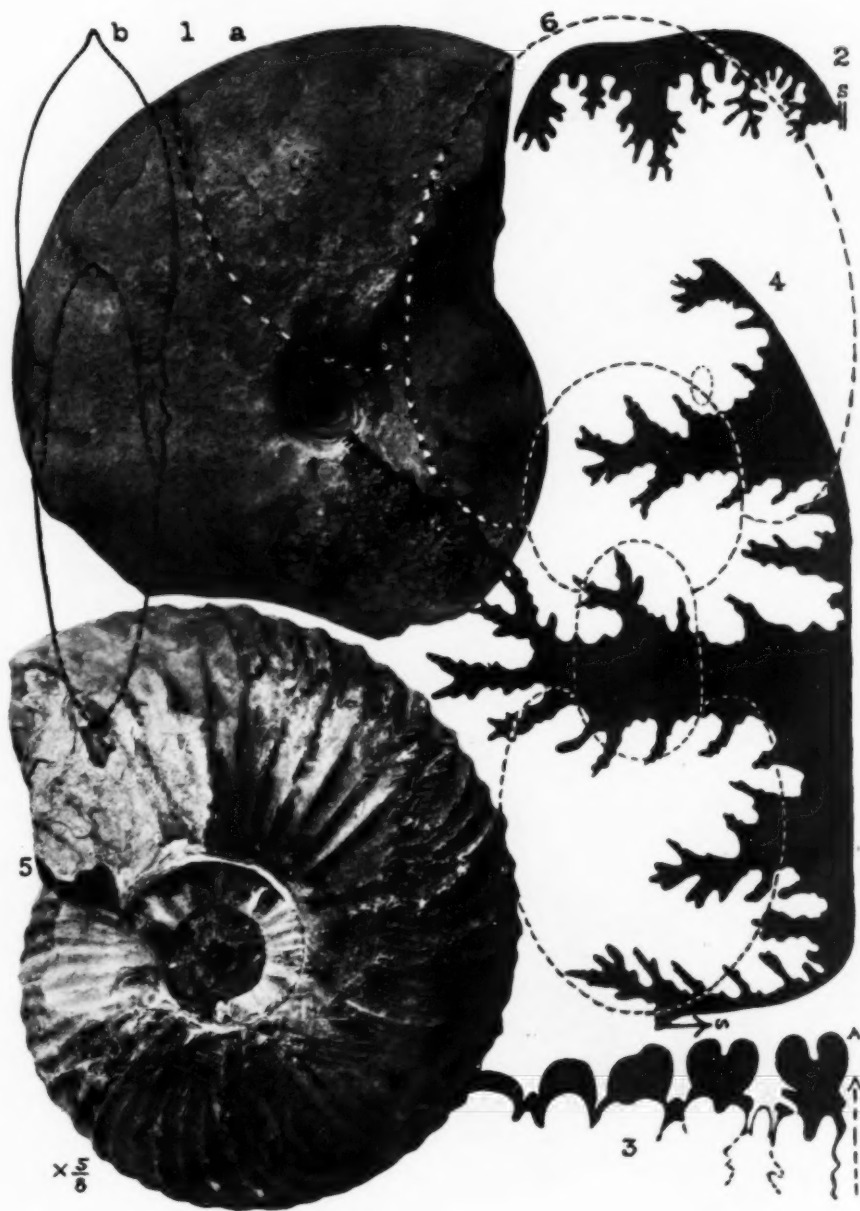
PLATE IX.

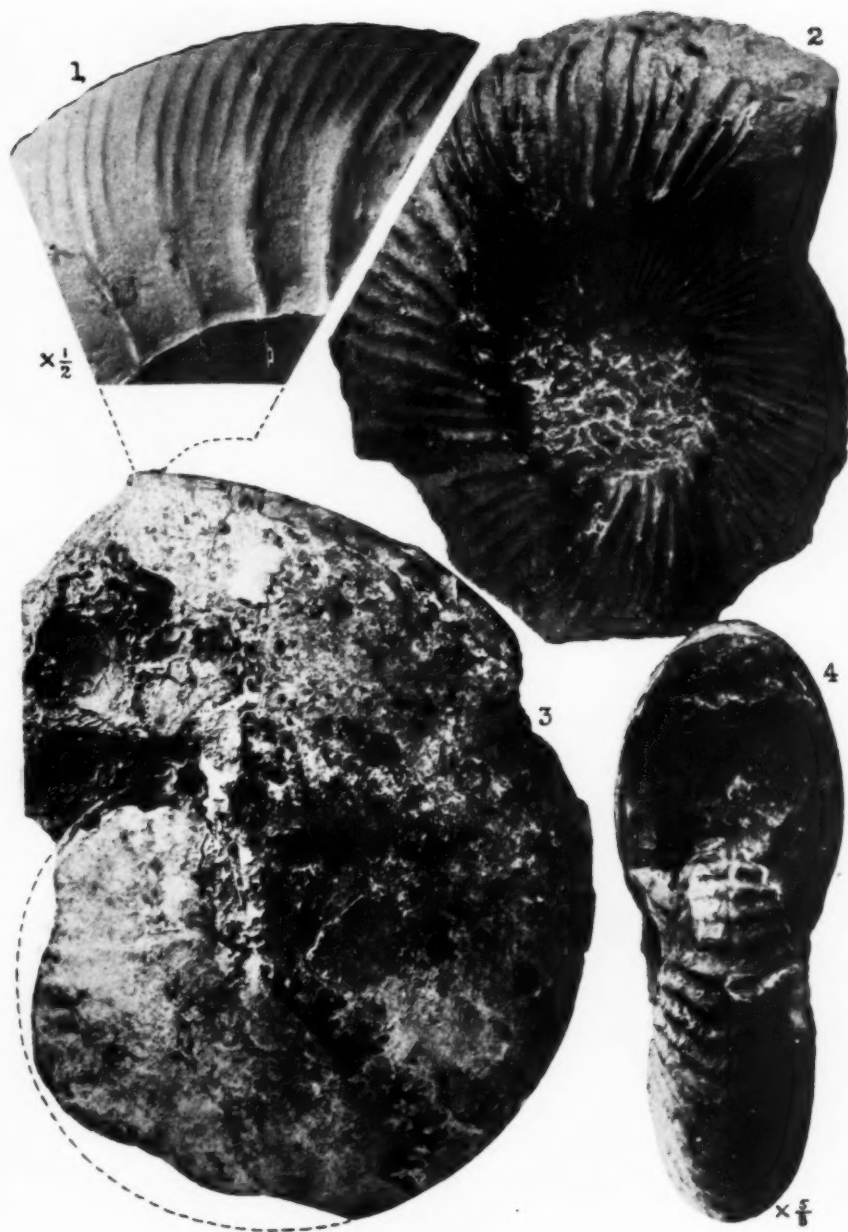
- 1a, b. *Pseudoschloenbachia papillata* (Crick MS.), Spath. Holotype, B.M., No. C 19430. Lateral and peripheral views. (P. 141.)
2. *Mortoniceras stangeri* (Baily), typus. B.M., No. C 19440. Reduced about $\frac{1}{2}$. Penultimate septum, figured in Spath, *loc. cit.* (Zululand), p. 297, fig. D 1c. (P. 137.)
- 3a, b. *Gaudryceras cinctum* (Crick MS.), Spath. B.M., No. C 19415. Lateral view and sectional outline. (P. 118.)
- 4a, b. *Parapachydiscus umtafanensis* (Crick MS.), Spath. Holotype, B.M., No. C 19434. Side-end peripheral views. (P. 133.)

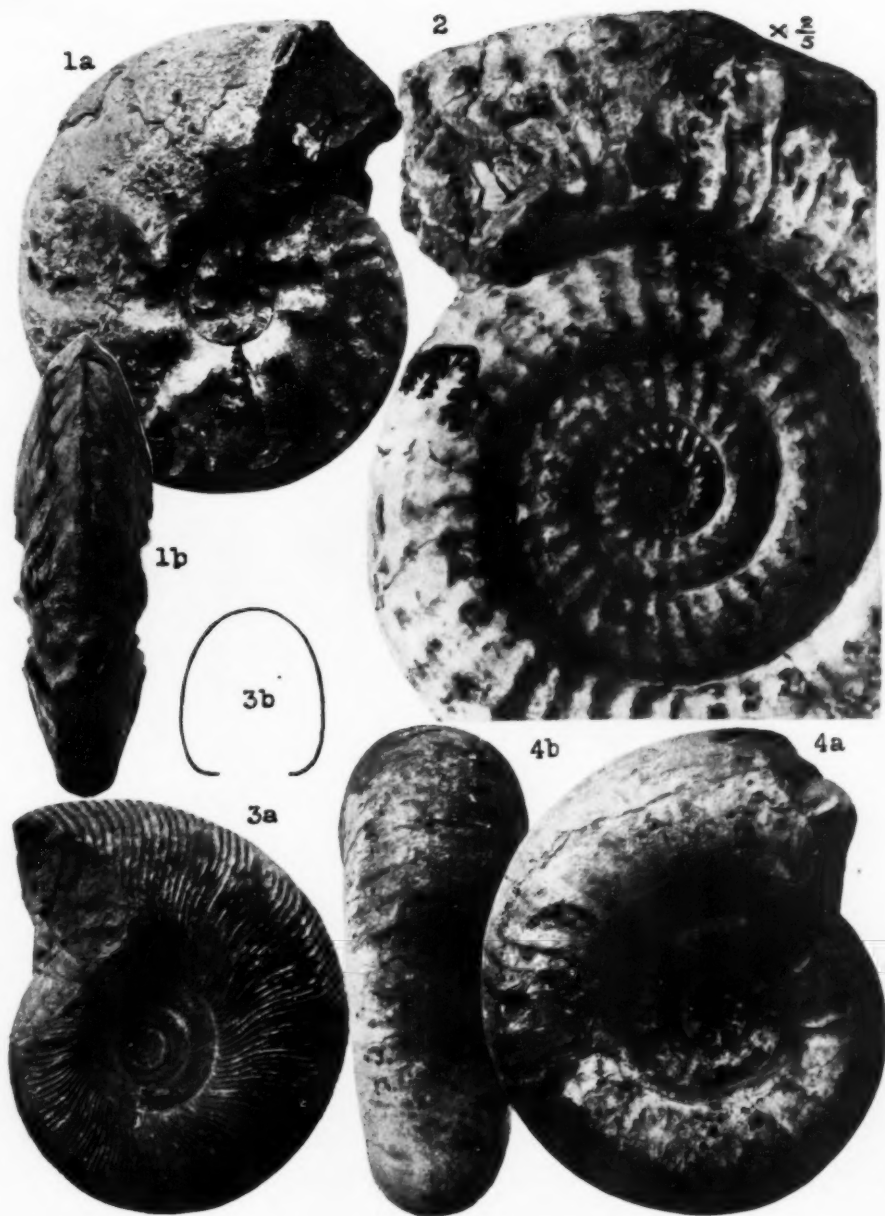
(All the examples are from the Umzamba Beds of Pondoland.)











A FUNGUS—*GIBELLULA HAYGARTHII*, SP. N.—ON A
SPIDER OF THE FAMILY LYCOSIDAE.

By PAUL A. VAN DER BIJL.

(With four Text-figures.)

In March 1921 Mr. W. Haygarth sent us from Krantz Kloof, Natal, a specimen (fig. 1) of a spider with an interesting fungus growing on it.



FIG. 1.

The fungus belongs to the genus *Gibellula*,* Cavara, and this collection is the first record of the genus from South Africa. It is evidently an undescribed species, and we suggest for it the name *Gibellula Haygarthii*, sp. n., and give the following brief diagnosis :—

Gibellula Haygarthii, sp. n., P. v. d. Bijl.

Coremia white, many from back of spider (fig. 1), terete, erect, unbranched, 1–3 mm. long \times 80–133 μ diam., base bulbous, 266–500 μ , apex more or less sterile for 133–173 μ ; fertile hyphae unbranched, covering sides of the coremia (fig. 2), entire height 35–266 μ , of two distinct segments,

* In the genus *Gibellula* the mycelium and conidia are colourless, and the conidia are aggregated together at the apex of conidiophores borne laterally on the coremia. These characters distinguish the genus from related genera.

lower segment $28-239\ \mu$ long $\times 6-7\ \mu$ diam., densely incrustated, rough, upper segment $18-26\ \mu$ long $\times 3-6\ \mu$ diam., faintly rough; head globular, basidia short and thick, $4-5-5 \times 3-5\ \mu$; sterigmata radiating from the basidia

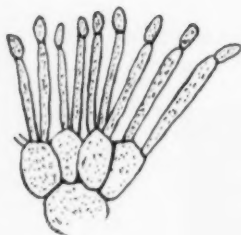


FIG. 4.

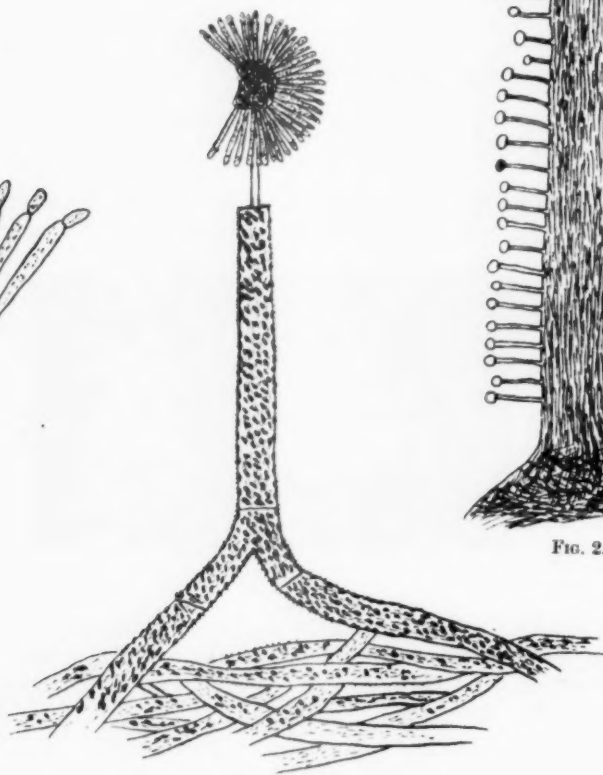


FIG. 3.

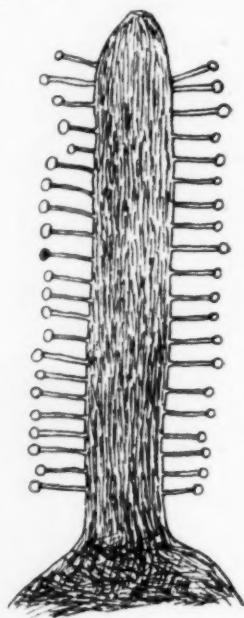


FIG. 2.

(fig. 4), $6-7-5\ \mu$ long $\times 1-5-2\ \mu$ diam.; spores hyaline, abstricted singly from apex of sterigmata, $3-6-4-4 \times 1-5\ \mu$.

Habitat.—On a spider of the family Lycosidae; collected by W. Haygarth at Krantz Kloof, Natal. The specimen was preserved in formalin, and it was hence not possible to grow the fungus and try inoculation experiments. The pathogenicity of these fungi requires investigation.

SOME SOUTH AFRICAN STEREUMS.

By PAUL A. VAN DER BIJL.

(With nine Text-figures.)

Very little attention has thus far been given to the South African fungi belonging to the family Thelephoraceae,* and of which the largest genus is undoubtedly *Stereum*.

Several species of this genus have so far been collected, and Mr. C. G. Lloyd kindly rendered assistance in identifying them.

They occur on trees and old logs principally, and a few grow on the ground. The fructifications of some species are stipitate, whereas others form shelf-like outgrowths on the wood or trees on which they grow or occur flat on these substrata. The hymenium or spore-bearing part is on the under surface of the fructification (except, of course, when these are flat on the substratum), and between the basidia there may be variously formed colourless outgrowths called cystidia.

While not at this stage attempting to give a key to the species, we will for convenience divide them into (1) Stipitate species, (2) Sessile species.

1. STIPITATE SPECIES.

Stereum glabrescens, Berk. and Curt. (Fig. 1.)

Plants stipitate, single, or a few rising from a common mycelial pad ;



FIG. 1.

* A smooth hymenium is characteristic of the Thelephoraceae, and the genus *Stereum* is distinguished from other genera of the family by its context tissue of several layers, of which the intermediate is normally composed of longitudinally arranged hyphae.

pileus flabelliform, 1.5-5 cm. long, 1.5-6 cm. broad, when young evidently at times infundibuliform and splitting on one side, zoned, finely velvety, chestnut-coloured; margin thin, lobed, lighter than pileus; stalk .5-1 cm. long \times 1-3 mm. thick, velvety, brown; hymenium even, pinky-buff, spores hyaline, subglobose, $4\ \mu$ diam.

Not an unfrequent fungus in the native bush of Zululand. W. Haygarth.

Stereum proximum, Lloyd. (Fig. 2.)

Plants usually growing densely clustered; pileus thin spatulate to suborbiculate, attached by a reduced base, upper surface finely velvety, light cinnamon to light ochre, partly glabrous with age, concentrically

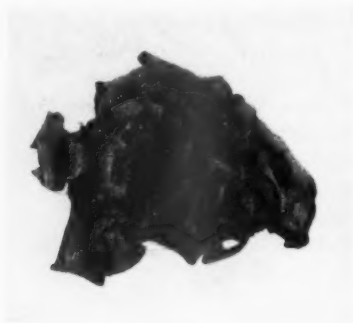


FIG. 2.

zoned, .5-5 cm. broad, 1.5-3.5 cm. high; hymenium reddish bay, with a waxy appearance; encrusted cystidia scanty, $49\ \mu \times 14\ \mu$, projecting beyond the hymenium; spores globose, $4\ \mu$ diam.

Gillitts, Natal. W. Haygarth.

The finely velvety surface, combined with habit of growth and waxy, reddish-bay hymenium, should aid in recognising this fungus.

2. SESSILE SPECIES.

Stereum australe, Lloyd. (Fig. 3.)

Pileus coriaceous, attached by the reflexed side or broadly centrally, densely tomentose, becoming concentrically furrowed, brown to ashy; about .5-1 mm. thick; margin entire; hymenium even, smooth, grey to light fawnish, with coloured conducting ducts (lactiferous ducts) which curve into the hymenium between the basidia; ducts, $4\ \mu$ diam.; spores hyaline, flattened on one side, $3 \times 4\ \mu$.

Occurs in Natal and the Transvaal.

Few *Stereums* have conducting ducts in the hymenium. Their presence should aid in recognising the above.

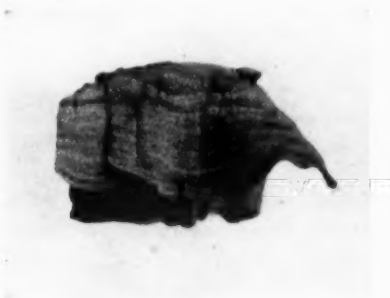


FIG. 3.

Stereum bicolor, Fr.

Plants sessile, largely resupinate; pileus soft, 1.5-3.5 cm. broad \times 1-1.5 cm. long \times .5-2 mm. thick, surface zonate or azonate, faintly villous, becoming glabrous, *light umber brown*; hymenium even, glabrous, *white*; intermediate tissue umber brown, darker than surface; cystidia encrusted, spores hyaline, $4-5 \times 3-4 \mu$.

Decaying wood at Durban, by P. van der Bijl.

This species is recognisable by its soft consistency, the contrast in colour between the upper and the under surface, and the colour of the intermediate layer.



FIG. 4.

Stereum cinereum, Lev. (Fig. 4.)

Plants sessile, effused—reflexed, pileus coriaceous, cuneate, thin, some-

what flexible to firm, laterally connate, 1.3-2.5 cm. broad \times 1.4 cm. long \times .5-1 mm. thick, surface concentrically zoned, sulcate, tomentose, brown to pale and ashy, margin undulate to lobed; hymenium even, pinky-buff, cystidia absent; spores hyaline, flattened on one side $4-5 \times 2 \mu$.

Gillitts, by W. Haygarth.

This appears close to *Stereum lobatum*, with surface more sulcate and more densely pubescent and general appearance more firm.

Stereum hirsutum (Wild.), Fr. (Fig. 5.)

Plants sessile, effused—reflexed, coriaceous, drying firm; pileus imbricate, surface strigose—hirsute, zoned, concentrically furrowed, ochraceous buff



FIG. 5.

becoming grey in age, connate, 1.5-4 cm. broad \times 1.5-6 cm. long \times 1 mm. thick; hymenium even, buff-coloured; spores hyaline, flattened on one side, $6.5-7.5 \times 2-2.5 \mu$; cystidia absent.

A very common fungus on old logs all over South Africa. Also a wound parasite on fruit and other trees.

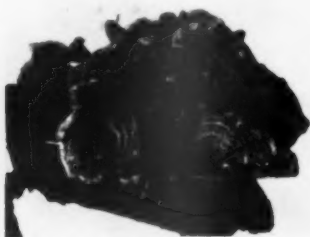


FIG. 6.

Stereum Kalchbrenneri, Mass. (Fig. 6.)

Plants sessile, pileus coriaceous, dimidiate to reniform, attenuated at

attachment, usually clustered, laterally connate, 3-4.5 cm. across, .5-1 mm. thick; surface concentrically zoned and furrowed, densely strigose, with bright cinnamon-brown hairs; hymenium smooth, ochraceous to lilaceous, spores (*teste* Massee) ellipsoid, hyaline, $7 \times 4.5 \mu$.

Locality.—Eastern Cape Province, on logs of *Rhus laevigata*, by J. D. Keet.

Like *St. vellereum*, this species is also close to *St. hirsutum*. The surface is brighter coloured, and the plants as a whole usually larger and more robust. Appears to be rare.

Stereum lobatum (Kunze), Fr. (Fig. 7.)

Plants sessile, imbricate; pileus coriaceous, thin, somewhat flexible, cuneate, laterally connate, narrowly attached; 5-10 cm. broad \times 3-7 cm. long \times .5 mm. thick, surface with multi-coloured zones, finely pubescent



FIG. 7.

to subglabrous; margin thin, undulate to lobed; hymenium even, pinky-buff, cystidia absent; spores hyaline, flattened on one side, $4 \times 1.5 \mu$.

A common South African species; Cape, Natal, and Transvaal.

Stereum durbanense, sp. n., P. v. d. B. (Fig. 8.)

Plants perennial, sessile, effused—reflexed; pileus thick, corky, drying firm and brittle, 2-6 cm. broad \times 1-3 mm. thick, imbricate; surface concentrically sulcate, tomentose, cinnamon, changing to grey in old specimens; margin entire; hymenium even, light fawn, spores hyaline, $3-4 \mu$.

At Durban on old logs.

St. subpileatum has encrusted cystidia. These we do not find in the Durban specimens. Apart from this, the specimen appears close to *St.*

subpileatum, and is so referred by Mr. Lloyd, who notes the absence of cystidia.



FIG. 8.

Stereum tomentosum, n. sp., P. v. d. B. (Fig. 9.)

Pileus coriaceous—corky, largely resupinate, with free margin, .5–1 cm.; surface tomentose with pad up to 1 mm. thick, tan to old gold and becoming chocolate with age, concentrically sulcate in better-developed specimens;



FIG. 9.

margin thick, entire; hymenium pale lilac; in structure 1–2 mm. thick (including pad), with a narrow, horny, reddish-brown zone beneath the pad, beneath which the tissue is a light fawn; spores not found.

Locality.—Collected at Durban on dead log by P. van der Bijl.

Stereum vellereum, Berk.

Plants thin, almost membranous, sessile or effused—reflexed; pileus coriaceous, tough, imbricate, laterally connate, often attenuated at attach-

ment, 1.5-2.5 cm. long \times 1-2 cm. broad \times .3 mm. thick ; surface densely strigose with greyish-white hairs, concentrically furrowed ; margin thin, entire to lobed, incurved in drying ; hymenium pale ochraceous, smooth ; spores (*teste* Massee) hyaline, subglobose, 4-5 μ .

Locality.—On old logs of *Quercus* sp. in the Paarl district, by P. van der Bijl.

Close to the common *St. hirsutum*, but thinner and paler in colour.

UNIVERSITY OF STELLENBOSCH,
STELLENBOSCH,
UNION OF SOUTH AFRICA.

COLOUR AND CHEMICAL CONSTITUTION.

PART XV.—A SYSTEMATIC STUDY OF FLUORESCIN AND
RESORCIN-BENZEINE.

By JAMES MOIR.

In Part XI of this work (These T., Vol. IX, part 2, p. 129) a systematic study of phenolphthalein was undertaken, as a result of which the colour-value of substitution (by bromine taken as a standard substituent) of every one of the twelve hydrogen atoms in this compound was approximately determined.

As the nature of this investigation does not seem to have been fully understood overseas, *e.g.* by the abstractor of the London Chemical Society, I think it desirable to reprint the results in another form, viz. that of the "dicyclic colour-factors" explained in Parts X and XIV.

Table of Colour-factors for Bromine in Phenolphthalein.

Bromine substituted for hydrogen in the <i>a</i> position = 1.0180				Colour-factor.	
"	"	"	"	<i>b</i>	" = 1.0020
"	"	"	"	<i>c</i>	" = 1.0145
"	"	"	"	<i>d</i>	" = 1.0180
"	"	"	"	<i>e</i>	" = 1.0270
"	"	"	"	<i>f</i>	" = 1.0145
"	"	"	"	<i>g</i>	" = 1.0145
"	"	"	"	<i>h</i>	" = 1.0270
"	"	"	"	<i>i</i>	" = 1.0235
"	"	"	"	<i>j</i>	" = 1.0125
"	"	"	"	<i>k</i>	" = 1.0125
"	"	"	"	<i>l</i>	" = 1.0235

Note.—The numeration of the positions is that given on p. 130 of Part XI, and is also repeated here under fluorescein.

Thus to calculate the colour of phenol-tetrabromophthalein (which is

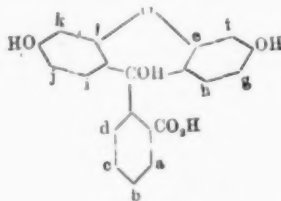
phenolphthalein with bromine for hydrogen in the *a*, *b*, *c*, and *d* positions), we have $\lambda_s = \lambda_0(554) \times 1.018 \times 1.002 \times 1.0145 \times 1.0180 = 583.6$.

Again, it was shown in Part IX, p. 225, that the factors for chlorine and iodine are almost the same as those for bromine. Putting in the numerical values into the algebraical formula given on that page, we find that the colour-factor for chlorine differs from that of bromine by 18×0.000037 , or 1 part in 1500, and that the colour-factor for iodine is greater than that of bromine by a like amount. Hence, for example, the calculated colour of phenol-tetrachlorophthalein is 583.6 (that of phenol-tetrabromophthalein just calculated) multiplied by $\left(\frac{1499}{1500}\right)^4$, chlorine having replaced bromine four times. This is 582.1. This agrees with observation, viz. $\lambda 581$ and $\lambda 582$ from two specimens. I am greatly indebted to Professors Partington of London and Mackenzie of Dundee for specimens of tetrachlorophthalic acid which they sent me after I had vainly tried to purchase it all over the world for three years.

Similarly, phenol-tetraiodophthalein should have $\lambda = 583.6 \times \left(\frac{1500}{1499}\right)^4 = 585.2$, but I have not been able to make (or obtain from its discoverer) this compound.

In the same way, the calculated colour of ordinary (*fgjk*) tetrabromophenolphthalein is $554 \times (1.0145)^2 \times (1.0125)^2 = \lambda 584.0$, and the calculated colours of tetrachloro- and tetriodophenolphthalein are $\lambda 584.0 \times \left(\frac{1499}{1500}\right)^4$ and $\lambda 584.0 \times \left(\frac{1500}{1499}\right)^4$ respectively. These agree with observation.

A. — Derivatives of Fluorescein.



Employing the same numeration of the positions as was used for phenolphthalein in Part XI, i.e. assuming that fluorescein is *e*-*l*-oxophenolphthalein, it is to be expected that the same colour-factors will hold good.

Unfortunately, the experimental difficulties have in some cases proved

too much for me, particularly as regards substitution in the λ and i positions.

The following table contains my observations (note: λ fluorescein $\approx 493\frac{1}{2}$):—

Substitution-products of Fluorescein.

	λ		λ
<i>a</i> -monobromo-	501	<i>a</i> -nitro-	500
<i>a</i> - <i>d</i> -dibromo-	509	<i>c</i> -nitro-	498
<i>c</i> -monobromo-	499	<i>a</i> -oxy-	{ 489 neutral 494 alkali
<i>a</i> - <i>c</i> -dibromo-	506	<i>b</i> - or <i>c</i> -oxy-	492
<i>a</i> - <i>c</i> - <i>d</i> -tribromo-	511*	<i>a</i> - <i>d</i> -dioxy-	493
<i>a</i> - <i>b</i> - <i>c</i> - <i>d</i> -tetrabromo-	514	<i>ad</i> -dimethoxy-	499
<i>a</i> -methoxy-	497	<i>b</i> - <i>c</i> -dimethoxy-	496
<i>b</i> - or <i>c</i> -methoxy-	492	<i>abc</i> -trimethoxy-	499
<i>a</i> - <i>b</i> - <i>c</i> -trichloro-	505	<i>a</i> - <i>f</i> - <i>g</i> - <i>j</i> - <i>k</i> -pentabromo-	529
<i>a</i> - <i>b</i> - <i>c</i> - <i>d</i> -tetrachloro-	513	<i>c</i> - <i>f</i> - <i>g</i> - <i>j</i> - <i>k</i> - "	526
<i>g</i> - <i>j</i> -dibromo-	509	<i>a</i> - <i>c</i> - <i>f</i> - <i>g</i> - <i>j</i> - <i>k</i> -hexabromo-	535
<i>f</i> - <i>g</i> - <i>j</i> -tribromo-	515	<i>a</i> - <i>d</i> - <i>f</i> - <i>g</i> - <i>j</i> - <i>k</i> - "	539
<i>f</i> - <i>g</i> - <i>j</i> - <i>k</i> -tetrabromo- } (eosine)	521	<i>a</i> -nitro- <i>f</i> - <i>g</i> - <i>j</i> - <i>k</i> -tetrabromo-	530
<i>g</i> - <i>j</i> -dimethyl- } (resorcin)	500	<i>c</i> - " " "	529
<i>f</i> - <i>k</i> -dibromo- <i>g</i> - <i>j</i> -dimethyl-	516	<i>f</i> - <i>k</i> -dinitro- <i>g</i> - <i>j</i> -dibromo- } ("methyleosine")	522
<i>h</i> - <i>i</i> -dimethyl- } ("γ-orcinphthalein")	489½	<i>f</i> - <i>g</i> - <i>j</i> - <i>k</i> -tetrachloro-	518
<i>f</i> - <i>g</i> - <i>j</i> - <i>k</i> -tetrabromo-, der. of above	521	<i>abcdfgjk</i> -octochloro-	537
<i>h</i> - <i>i</i> -dioxy- (phloroglucin- } phthalein) { 489 neutral 494 alkali		" -octobromo-	544
<i>h</i> - <i>i</i> -dimethyl- <i>abcd</i> -tetrachloro-	511½	<i>f</i> - <i>g</i> - <i>j</i> - <i>k</i> -tetriodo- } (erythrosine)	525
<i>a</i> - <i>c</i> -dichloro- <i>fgjk</i> -tetrabromo-	538	<i>acdfgjk</i> -heptabromo-	540
<i>b</i> - <i>c</i> - " " " " } (Phloxin M)	529	<i>abc</i> -trichloro- <i>fgjk</i> -tetrabromo-	536
<i>abcd</i> -tetrachloro- <i>fgjk</i> -tetrabromo- } (Phloxin proper)	544	<i>abcd</i> -tetrachloro- <i>g</i> -iodo-	520
<i>abcd</i> -tetrachloro- <i>fgjk</i> -tetraiodo- } (Rose bengale)	548	" " <i>g</i> -iodo- <i>fkj</i> -tribromo-	543
[" <i>a</i> -orcinphthalein"	520 vague]	[" <i>β</i> -orcinphthalein"	440†
Oxyquinolphthalein	550+527+509	[" <i>Tribromo-β</i> -orcinphthalein"	463]
		[" <i>Quinolphthalein</i> "	{ 494 neutral 499 alkali]
		Oxyquinoltetrachlorophthalein	577+530

* This may be *abd*: there is no means of deciding.

† The substances in brackets are related to fluorescein but are not direct derivatives.

It is probably unnecessary to describe the method of preparation of any of these substances, the information in Part XI about derivatives of phenolphthalein sufficing by analogy. It may be noted also that positions f and g are radically different in fluorescein, although they are almost the same in phenolphthalein. I have assumed, in assigning constitutions to these substances, that a substituent will enter the g and j positions first, since the other two *ortho*-positions, f and k, are "protected" by the oxo-linkage.

Deductions from the Observations.

A. The observations become consistent for the four "phthalic" positions, a, b, c, and d, if we assume *a*-monobromo- = *d*-monobromo- = +8, and also assume *b*-monobromo- to have no effect, and *c*-monobromo- = +4½.

Hence *a*-monobromo colour-factor in fluorescein = 1.0162

<i>b</i> -	"	"	"	=1.0000
<i>c</i> -	"	"	"	=1.0091
<i>d</i> -	"	"	"	=1.0162

These four factors therefore are smaller than those obtained for phenolphthalein, but their mutual variations resemble those of the phenolphthalein series, and the actual discrepancy is not much more than 1 part in 500, or than the error of observation. It follows therefore that the phthalic part of the fluorescein molecule does not differ much spatially from the phthalic part of the phenolphthalein molecule.

B. It has been impossible to make monobromo-compounds of the fgjk class, but by difference I estimate that f-bromo = k-bromo = +6, and that g-bromo = j-bromo = 7½.

Hence f-monobromo colour-factor in fluorescein = 1.0122

<i>g</i> -	"	"	"	=1.0157
<i>j</i> -	"	"	"	=1.0157
<i>k</i> -	"	"	"	=1.0122

These four factors are not smaller than those obtained for phenolphthalein, and vary irregularly like an experimental error: nevertheless I think the small differences are real, and are due to the presence of the oxo-linkage.

As already stated, the *h* and *i* bromo colour-factors could not be ascertained by direct experiment. By inference from γ -orcinphthalein and phloroglucin-phthalein, however, I find them to be less than unity, viz. both the *h*-monobromo and the *i*-monobromo colour-factors are

about 0.990. This is completely discrepant with the phenolphthalein figures.

C. The chloro-derivatives follow as before from the bromo-derivatives by multiplying by $\frac{1499}{1500}$ as often as the change from bromine to chlorine is made.

D. The nitro-derivatives are not materially different from the bromo-derivatives. The a-, d-, g-, and j-nitro colour-factors are all about 1.016, and the c-, f-, and k-nitro colour-factors are all about 1.012.

E. The methyl colour-factors are considerably smaller than the bromo ones, the methoxyl colour-factors are smaller still, say 1.006 for the biggest of them, viz. the *a*-methoxyl, and the hydroxy colour-factors are smallest of all, practically unity. Indeed, when caustic alkali is employed all the oxy-derivatives of fluorescein have their absorption band in the same place as that of fluorescein. Gallein and oxyquinolphthalein constitute exceptions to this rule.

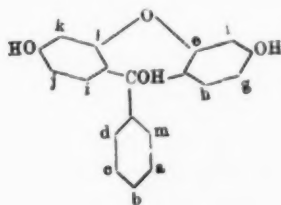
Two examples of the method of calculation may be given:—

1. *Octobromofluorescein*: $\lambda_x = 493.5 \times 1.0162 \times 1.0091 \times 1.0162 \times 1.0122 \times 1.0157 \times 1.0122 \times 1.0157 = 543.0$. The observed value was 544.

2. *Octochlorofluorescein*: $\lambda_x = \lambda$ for octobromofluorescein $\times \left(\frac{1499}{1500}\right)^8$.

This is 540.0. The observed value was 537. Further experiment may show that the ratio Cl/Br is not so near to unity, the error only showing in this extreme case.

B.—Derivatives of Resorcin-benzeine.



Resorcin-benzeine is phenyl-2-7-dihydroxy-xanthhydrol and is fluorescein minus the CO_2H group. The same numeration is therefore used, with *m* for the position occupied by the new hydrogen. Resorcin-benzeine in alkaline solution appears identical with fluorescein in colour and intensity of fluorescence. The absorption-band is at λ 492.

Substitution-products of Resorcin-benzeine.

	λ		λ
a- or c-oxy-	$\left\{ \begin{array}{l} 494 \text{ neutral} \\ 492 \text{ alkaline} \end{array} \right.$	b-bromo-	493
b-oxy-	$\left\{ \begin{array}{l} 484 \text{ neutral} \\ 492 \text{ just alkaline} \\ 544 \text{ alkaline} \end{array} \right.$	a- or c-bromo-	497
b-methoxy-	493	a- or c-bromo-b-oxy-	$\left\{ \begin{array}{l} 490 \text{ neutral} \\ 550 \text{ alkaline} \end{array} \right.$
d- or m-oxy-	430 + 492	d- or m-bromo-	505
d- or m-sulphonic acid	$\left. \right\} 498$	b-nitro-	500
"resorcin sulphophthalein"		fjgk-tetrabromo-	519
fjgk-tetrabromo-m-sulphonic acid	527	fjgk-tetrabromo-b-nitro-	527
		b-nitro-d- or m-sulphonic acid	506

It is to be noted that the list is limited from the fact that sulphuric acid cannot be used as condensing agent in making derivatives of resorcin-benzeine, because at an elevated temperature resorcin itself condenses to a coloured fluorescent compound "resorcin-ether," the nature of which is at present unknown. It has a dirty rose colour in alkali with $\lambda\lambda$ 490 and 550 and a bluish-green fluorescence. Phosphorus oxychloride, if not overheated, forms a suitable condensing agent.

The conclusions to be drawn in the case of resorcin-benzeine are :—

A. The *f*, *g*, *j*, and *k* colour-factors are the same as those of phenolphthalein and fluorescein, viz. about 1.0135 on the average for bromine taken as standard. Further experiment is necessary to decide whether the *g*-factor is greater than the *f*-factor, and whether the *g*- and *j*-factors are identical, as they should be by symmetry.

B. In the phenyl ring the effect diminishes in the order *d*, *c*, *b*, but in this case the effect is still positive at *b*, although it appears to be *nil* in fluorescein and is sometimes negative in benzaurine. Much further work is necessary to clear up these small anomalies.

Addendum, 12th June 1922.—Professor G. T. Morgan kindly sent me a sufficient specimen of 1-3-dioxynaphthalene to enable naphthofluorescein to be made and examined. It has $\lambda\lambda$ 535 and 496. The ortho-meta naphthol/phenol factor is thus 1.042 in the dicyclic series. This could not be ascertained from naphtholphthalein, because the latter is a diortho-compound and therefore cannot be compared with phenolphthalein. This naphthalene factor can be employed to calculate the naphthosafranines and naphthacridines.

The effect of the naphthalene ring in the dicyclic series is practically the same as that of two bromine atoms substituted in the *gh* or *ij* positions : i.e. the *outer* carbons of the naphthalene ring have almost no effect. This is of great theoretical importance.

THE "ACCOUNT-BOOK" OF JAN HASZING.

By C. PIJPER, M.D. (Leiden), Johannesburg, and
H. ZWARENSTEIN, M.B., Capetown.

Jan Haszing practised as a surgeon at Capetown in the middle of the eighteenth century. His "Account-book," which in some way or other has found its way to the archives at Capetown, starts at 1736 and runs on continuously till 1767. The following pages contain a verbal transcript of some of its entries, together with an English translation. They give some idea of what medical practice was like then in an "outpost" like Capetown. No explanations or footnotes are necessary; we only beg to draw attention to the fact that the Rd. ("rix-dollar") was divided into eight "schellings" (sixpences). It is a pity that our colleague occasionally has forgotten to note down for himself what he charged his patients; may we infer that medical men were but indifferent bookkeepers even then?

[AANTEKENINGH.

AANTEEKENINGH OFF SCHULT BOEK VAN JAN HASZINGH
CHIRURGIJN. Beginnende Ao. 1736.

1763. Christiaan Persoon Deb.

Den 28 Febr:ij uw huysvrouw met den chirurgijn Uijting gevisit:d.
lab: aan een febris Biliosa dewelke in een febris Hectica nader-
hand overging. Wijdersdaagts een en tweemaal geṽ: tot den
8 Maij. dat overleeden is komt voor practijk en visitens
samen - - - - - Rds. 25.

Den Inhoud deses Voldaan.

1765. Mons: Pieter Soermans Deb:

5 N:r Uw beminde seer gelukkig van een dood kind 'twelk een
waterbuijkje had verlost en waarvan de placenta op een extra
ordinaire wijze vast zat, sodat deselve met veel moeite moest
afgehaald worden. Verder 't nodige in 't kraambed besorgt
en wederom volkome herstelt.

Ten dank voldaan.

1765. Juff:w D: Wed:we Hazewinkel Deb.

18 Junij Ued: met de Heeren practizijns Van der Riet, Nelson, d:
Vrij en van Nierop, geṽ: lab: aan Colica Biliosa beneevens een
consid:ble Hernia umb: komt voor gedaane consultatien en
visitens tot den 1 Julij samen - - - - - Rds. 10.

Den Inhoud deses Voldaan.

1766. Den Adsist Alleman

Deb.

15 Augts: Voor uw huisvrouw 1 bott: Gaṽg.	„ -4
20 - - : „ „ Een bott: viñ: medicat:	„ -6
21 - - : „ „ 1 flesje Elir: stoṁ c: tet: absinte	„ 1-
27 - - : Voor uw kind 1 flesje sp: nitr: dulē:	„ -4
29 - - : „ „ een dos: sirp: cich: c: Rhas 1)	„ -4
1 Sbr: Voor uw huysvrouw 1 haust: Corral 2)	„ -2
3 Sbr: Voor ad jdem - - - - -	„ -2
5 - - : „ „ 1 ḡ: flesje sp: carṁ: silṽ: c: tet: Castorii	„ 1-4
22 - - : Voor de meyd Lea 1 Flesje sp: nitr: dule	„ -4
28 - - : „ „ ad jdem - - - - -	„ -4

REGISTER OR ACCOUNT-BOOK OF JAN HASZINGH, SURGEON.

Beginning Ao. 1736.

1763. Christiaan Persoon, Deb.

28 Febr. Went to your house, together with surgeon Uijting, to see your wife, suffering from febris biliosa, which later on changed to a febris hectica. Thereafter every day one or two visits up to 8th May, the date she died; comes for treatment and visits together Rds. 25

Paid.

1765. Pieter Soermans, Esq., Deb.

5 Nov. Your beloved very successfully delivered of a dead child which had a water-swollen abdomen, while the placenta was fixed in an extraordinary way, so that the removal was attended with great difficulty. Thereafter attended to the lying-in, resulting in complete recovery.

Paid with thanks.

1765. The Widow Hazewinkel, Deb.

18 June. Came to your house, together with the doctors Van der Riet, Nelson, d. Vrij and van Nierop; found you suffering from colica biliosa complicated by a considerable hernia umbilicalis; comes for consultations and visits up to 1st July . . Rds. 10

Paid.

1766. The Assistant Alleman, Deb.

15 Aug.	For your wife, 1 bottle gargarism . . . . .	..	-4
20 "	" " 1 bottle vinum medicat. . . . .	..	-6
21 "	" " 1 vial elix. stomach. c. tinct. absinthii . . . . .	..	1-
27 "	For your child, 1 vial spirit. nitr. dulc. . . . .	..	-4
29 "	" " a dose syrup. cich. c. rhas. 1) . . . . .	..	-4
1 Sept.	For your wife, 1 haust. corral 2) . . . . .	..	-2
3 "	" " the same . . . . .	..	-2
5 "	" " 1 vial spirit. carmin. sylv. c. tinct. castorii . . . . .	..	1-4
22 "	For the servant-girl Lea, 1 vial spirit. nitr. dulc. . . . .	..	-4
28 "	" " the same . . . . .	..	-4

11 Obr:	Voor een meyd een Vomēt: - - - -	„ -3
12 „ „ :	„ „ een haust: carmin: - - - -	„ -2
26 Xbr:	Voor uw huijsvrouw 1 haust: carm: Annod:	„ -3
	Overgedaane Visitens van tijd tot tijd same	„ 20-
Somma		Rds. 27.2

Den Inhoud deses Voldaan.

1) ? 2) ?

1766. Anthony Barrange de Jonge Deb:

1 Maj	Uw meyd Gev: met een Consid:ble Antrax beneevens Verscheyde farunculae aan de Rug en geneese	Rds. 4.4
26 - - :	Jonge gev: met een gecond: solutie aan de groote toon en geneesen	Rds. 1.4
1 Julij	Voor UE en huysvrouw ieder een purg:	„ 1-
9 - - :	„ „ UE een bott: garg:	„ 4
10 - - :	Voor Uw huysvrouw ad jdem	„ -4

Somma Rds. 8-

Den Inhoud deses Voldaan.

1766. Jan Victor Eelders Deb:

2 Maj	Uw huysvrouw met de Heere d: Vrij & V: Nierop gev: Lab: aan een febris ardentis sijnde ontrent — maande swanger vervolgens geconsul: & gepract: tot den 12-: sijnde same 20 visitens	Rds: 6-
21 - - :	Wederom alleen ob nieuws gev: 'snagts ge- aborteerd hebbende sijnde flux: Loch: seer wijnig waar voor 't nodige besorgt tot volkome herstelling gelijk meede Lab: aan verscheyde farunculus in de nek daags verb: & geneesen	6

Somma Rds. 12-

Den Inhoud deses Voldaan.

11 Oct.	For a servant-girl, a dose of emetic	„	-3
12 „	„ a haust. carmin.	„	-2
26 Dec.	For your wife, 1 haust. carmin. anodyn.	„	-3
	For visits	„	20-

Together Rds. 27-2

Paid.

1) ? 2) ?

1766. Anthony Barrange de Jonge, Deb.

1 May.	Visit to your servant-girl, suffering from a considerable anthrax and several furuncles on the back; cured same	Rds.	4-4
26 May.	Visit to your house-boy, suffering from an inflamed contusion in his great toe; cured same	Rds.	1-4
1 July.	A purgat. for yourself and one for your wife	„	1-
9 „	A bottle of gargarism for yourself	„	4
10 „	The same for your wife	„	4

Together . Rds. 8-

Paid.

1766. Jan Victor Eelders, Deb.

2 May.	Went to see your wife, together with the doctors de Vrij and van Nierop; found her suffering from a febris ardentis while being about — months pregnant; for consultations and treatment up to 12th May, 20 visits altogether	Rds.	6
21 May.	Came to see her again, alone, having passed an abortion during the night, the flux. loch. being very scanty; done what was necessary to remedy this, with perfect success; treated her at the same time for furuncles in the neck, dressed those daily, cured same		6

Together . Rds. 12

Paid.

1766. Mons: Michiel Smuts Deb:

4 Maij	Voor UE een purg:	Rds. -4
18 Julij	Uw klijn dogtertje ge \bar{v} : Lab: aan een febris ardentes waar voor de noodige med: besorgt tot med: Augt:s & geneese komt voor practijk visitens & gel: med: same	6-
26 - - :	Voor uw dogter Maria 1 bott: Gar \bar{g} :	-4
27 - - :	Voor uw dogters Barbara & Maria jd: & 1 pur \bar{g} :	1-
18 Augt:s	Voor de oude Jonge 1 pl: Resol \bar{v} : op Leer	-4
22 „ „ :	de klijne jonge ge \bar{v} : met een gecontund: solutie in de pink, waarvan de nagel weggenome Verders daags verbonde & geneese komt voor de geneesing	2-
6 Sept:r	De meijd Gilida gevisit: Lab: aan een Con- sid:ble geinphlameerde keel overgaande skielijk tot gang \bar{r} : & sphacelus sijnde ons een singulier en sorglijk geval 'twelk verder door de Heer van Nierop behandelt en door mij de medica \bar{m} : besorgt sijn komt voor practijk visitens en gel: medica \bar{m} : samen	10
17 - - :	De madagascarse jonge gevisit: met een consid:ble solutie aan de hiel beneevens contusie aan de tendo Achilles 't selve daags verb: den tijd van ontrent 2 maande & geneese	6-
12 Octob:	Uw dogter Maria gevisit: met een geobstru- eerde knie uijt een sinking stoffe veroor- saakt waar voor 't noodige besorgt en geneesen	3-

Somma Rds. 29.4

Den Inhoud deses Voldaan.

1766. Juff:w D: Wed:we Abel Deb:

5 Maij	De Jonge Jacob gevisit: met een solutie inde Vinger & geneesen	Rds: 1.4
18 Junij	Een Vomet:	„ 4
10 Ob:r	Voor Een flesje oogwater	„ 4

Den Inhoud deses Voldaan.

Rds: 2.4

1766. Michiel Smuts, Esq., Deb.

4 May.	A purgative for yourself	Rds.	4
18 July.	Came to see your little daughter, suffering from a febris ardent, wherefore I supplied the necessary remedies till medio Aug. and cured her; comes for treatment, visits, and medicine	„	6-
26 „	For your daughter Maria, 1 bottle gargarism .	„	-4
27 „	For your daughters Barbara and Maria, 1 bottle of gargarism each and 1 dose of purgative .	„	1-
18 Aug.	For the old house-boy, 1 resolv. plaster on leather	„	-4
22 Aug.	Came to see the young house-boy, suffering from an inflamed contusion in the pink, wherefore I took away the nail. Thereafter daily dressings and cured; comes for the cure	„	2-
6 Sept.	Came to see the servant-girl Gilida, suffering from a considerably inflamed throat promptly developing into gangraena and sphacelus; this being a singular case which has caused us much anxiety; further treated by doctor van Nierop, the medicines being supplied by me; comes for treatment, visits, and medicines together	„	10-
17 „	Came to see the Madagascar boy, suffering from a considerable inflammation in his heel, complicated by a contusion in the tendo Achilles; dressed the same daily for a period of about two months and cured same	„	6-
12 Oct.	Came to see your daughter Maria, suffering from an obstructed knee arising out of a fluxion; performed what was necessary and cured	„	3-

Together . Rds. 29.4

Paid.

1766. The widow Abel, Deb.

5 May.	Came to see the house-boy Jacob, suffering from an inflammation in his finger; cured same .	Rds.	1.4
18 June.	An emetic	„	4
10 Oct.	Eye-wash	„	4

Paid,

Rds. 2.4

1766. Den Eerw: Heer Serrurier Deb:

16 Maj	Snagts of smorgens vroeg uw oudste dogtertje ge \bar{v} : met convulsio & St: Vitus Dans waar voor ettelijke Rijsen geclisteerd. Verder de noodige med: besorgt tot den 24- & geneesen	Rds. 4
28 - -	: Uw Eerw: ge \bar{v} : Lab: aan Angina die seer hard-neckig was wederstreevende veele middele en waar voor de nodige med: zijn besorgt tot pr:mo Julij & geneese	„ 5
25 Junij	UE beminde Ge \bar{v} : met inphlamatie in de keel waar voor 't nodige besorgt en geneesen	„ 3
6 Aug: s	Voor uw oudste dogtertje Een purg:	„ -4
15 - -	: „ „ ad jdem	„ -4
10 7b:r	: „ „ 1 flesje Collirium	„ -4
23 - -	: „ „ Een ons man \bar{n} : Calabr:	„ -4
7 8b:r	: „ „ ad jdem	„ -4
18 X:br	Voor UE beminde 1 purg: & 1 bott: garg:	„ 1

Somma Rds: 15.4

Hiervoor Ten Dank Voldaan.

1766. Matthijs Van Wieling d: Jonge De \bar{b} :

24 Maj. Uw vrouw Ge \bar{v} : klagende over swaare naween alsoo daags bevoorens hadde geaborteerd waar voor 't nodige besorgt en geneesen.

Ten dank Voldaan.

1766. De Wed:we N:s Mulder Debet.

15 Junij	UE Ge \bar{v} : met een sware coorts waar voor de nodige med: besorgt & geneesen komt voor practijk Visitens en Gel: medicam: same	Rds. 6.
1 Julij	Voor de Jonge Thomas Een purg:	„ .3
5 Julij	: „ „ ad jdem	„ .3

Somma Rds. 6.6

Den Jnhoud deses Voldaan.

1766. The Rev. Serrurier, Deb.

16 May.	Came to see, during the night or early morning, your eldest daughter, suffering from convulsions and St. Vitus's dance; wherefore I administered several clysters. Thereafter I supplied those medicines as were necessary (till the 24th), and cured her	Rds. 4
28 „	Came to see your Reverence, suffering from a very obstinate angina, which several medicines had been unable to conquer; wherefore I supplied medicines up to 1st July, and cured same	„ 5
25 June.	Came to see your beloved, suffering from inflammation in her throat; wherefore supplied what was necessary, and cured	„ 3
6 Aug.	A dose of purgative for your eldest daughter	„ -4
15 „	The same	„ -4
10 Sept.	An eye-wash for same	„ -4
23 „	One ounce of mann. calabr.	„ -4
7 Oct.	The same	„ -4
18 Dec.	One dose of purgative and 1 bottle of garg. for your beloved	„ 1
	Sum total	15.4

Paid with thanks.

1766. Matthijs van Wieling, Junior, Deb.

24 May. Visited your wife, complaining about severe after-pains, having suffered an abortion the day before; wherefore done what was necessary, and cured.

Paid with thanks.

1766. The widow N. Mulder, Deb.

15 June.	Came to see yourself, suffering from a serious fever; wherefore supplied what was necessary, and cured; comes for treatment, visits, and medicines	Rds. 6
1 July.	A dose of purgative for your house-boy Thomas	„ -3
5 „	The same	„ -3
	Together	Rds. 6.6

Paid.

1766. Mons: Thobias Rogiers Deb:

4 Julij Uw huysvrouw verlost van een vrugtje van ontrent 3
maande 'twelk bijna gebore was, en waarop Verder ontlasting
Van een mola, en een verrotte placenta volgde. Verder
't nodige besorgt & herstelt.

Ten dank Voldaan.

1766. Christiaan Pieter Brand Deb:

8 Julij	Uw vrouw geaborteerd hebbende en geen placenta gevolgd sijnde waar voor late clisteeren en verder de benodigde med: besorgt tot volkome herstelling	Rds: 6.-
21 Augt:s	Voor uw Jonge Een Vomet:	„ -3
„ „	Een purgē:	„ -3

Somma Rds: 6.6

Den Inhoud deses Voldaan.

1766. Rijnier Keet Debet.

14 Julij	Uw vrouw geṽ: Lab: aan een sware bloedstorting waarop door 't gebruik van gepaste med: en 't sette van eenige clisteeren ontlasting van een mola gevolgd is.	
12 Augt:s	„ op nieuws wederom geṽ: hebbende reets 10 dagen lang sterk gevloeit hier voor wederom de nodige medicaṁ: besorgt tot pr:mo 7b:r & geneese: komt voor practijk, visitens en Gel: medicaṁ: same	Rds: 10.

Den Inhoud deses Voldaan.

1766. Pieter Malet Debet.

16 Julij Uw huysvrouw seer gelukkig & voorspoedig verlost van
een kwalijck gekeert kind 'twelk een levendige soon was—
verder 't nodige int kraambd besorgt tot volkome herstelling—

Ten dank Voldaan.

1766. Thobias Rogiers, Esq., Deb.

4 July. Delivered your wife of a fœtus of about three months which was very nearly born, and whereafter a mola and a putrid placenta came to light. Thereafter done what was necessary, and cured.

Paid with thanks.

1766. Christiaan Pieter Brand, Deb.

8 July. Your wife having suffered an abortion where no placenta had come to light, clysters administered to her and supplied what was necessary, resulting in complete recovery . Rds. 6

21 Aug. An emetic for your house-boy " -3

A purgative for same " -3

Together . Rds. 6.6

Paid.

1766. Rijnier Keet, Deb.

14 July. Came to see your wife, suffering from a severe hæmorrhage, whereupon appropriate medicines and the administering of some clysters brought to light a mola.

12 Aug. Came to see her again, having suffered already for the last ten days from severe loss of blood; supplied what was necessary up till 1st Sept.; comes for treatment, visits, and medicines together Rds. 10

Paid.

1766. Pieter Malet, Debet.

16 July. Delivered your wife very successfully and prosperously of an awkwardly bent-up child, which turned out to be a living son; supplied what was necessary for the lying-in, resulting in complete recovery.

Paid with thanks.

1766. Juff:w Elsje Colijn*Deb:

26 Julij	Voor UE na de Verlossing een ord: drank tot voortsetting van de kraam en van de naween	Rds: 1-
15 7b:r	Voor Een purg:	" -4
28 - - :	" " ad jdem	" -4
28 Ob:r	" " ad jdem	" -4
1 Xb:r	Voor 'tkind 1 ons manñ: calabr:	" -4

Somma Rds: 3-

Den Inhoud deses Voldaan.

1766. D. Wed:we Huijsman Debet

28 Aug:t:s Haar E: met de praktizijns V: Nierop & Nijting geṽ: Lab:
aan een duyster & singulier geval in de buijk denkelijk door
geobstrueerde ingewande voortgebracht & waarvoor een grote
pL: op Leer vande EmpL: Rustingii 1) geappld: hebbe ben-
evens verscheijde onse sp: sal: vol: ol: om te ruijke komt
voo gel. medicañ: beneevens eenige gedaane consultatien,
& Visit:s same

Rds: 5-

Segge Voldaan.

1) ?

1766. Joh:s Guil:m V. Helsdinge Deb:

1 Obr: Uw vrouw int kraambd geṽ: klagende over swaare pijn
in de buijk Etx: Waar voor eenige rijse doen clisteeren verder
't nodige besorgt en geneesen.

Ten dank Voldaan.

1766. D: Paruijkemaker Jonii Debet.

4 8b:r Uw vrouw geṽ: Lab: aan flux: menss: waar voor 't nodige
besorgt & geneese.

Rds: 1.4

Hier Van Voldaan.

1766. Dirk D: Jongh Debet.

16 9b:r Uw meyd seer gelukkig van een dood kind verlost verder
'tnodige besorgt & hersteld.

Ten dank Voldaan.

1766. Mrs. Elsje Colijn, Deb.

26 July.	For yourself, after the confinement, the ordinary mixture to succour the lying-in and the after-pains	Rds. 1-
15 Sept.	A dose of purgative . . . . .	.4
28 "	The same . . . . .	.4
28 Oct.	The same . . . . .	.4
1 Dec.	1 ounce of mann. calabrin. for the child . . . . .	.4

Sum total . Rds. 3-

Paid.

1766. The widow Huijsman, Debet.

28 Aug. Visited your Honour (together with the doctors van Nierop and Nijting), suffering from a perplexing and singular affection in the abdomen, probably caused by obstructed intestines, wherefore we applied a large plaster of empl. rustingii 1), on leather, while at the same time we made you snuff up several ounces of spir. sal. vol. ol.; comes for medicines, together with consultations and visits . Rds. 5

Paid.

1) ?

1766. Joh. Guil. V. Helsdinge, Deb.

1 Oct. Visited your wife during her lying-in, complaining about severe pains in her abdomen, etc.; caused her to be clystered a couple of times, and supplied what was necessary; cured.

Paid.

1766. The wig-maker Jonii, Deb.

4 Oct. Visited your wife, suffering from flux. mens.; wherefore supplied what was necessary, and cured . Rds. 1.4

Paid.

1766. Dirk de Jongh, Debet.

16 Nov. Your servant-girl very successfully delivered of a dead child; supplied what was necessary, and cured.

Paid.

1766. Mons:r Poul:s Hen:s Eksteen Deb.

21 9b:r UE beminde seer gelukkig van een levendige soon met een geklemt hoofd op zijn Rhoonhuysiaans verlost sonder eenige beletselen dog 'tkind ontrent 18 uren hierna overleden. Verder de moeder int kraambed van 'tnodige besorgt en volkome hersteld.

Ten dank Voldaan.

1766. De Boode Ab:m Paling Deb:

13 Xb:r Uw meyd gelukkig van een kwalijk gekeert dood kind verlost na lang in arbeid geseten te hebben verder 'tnodige besorgt tot volkome gesontheid.

Ten dank Voldaan.

1766. De Wed:we Michiel de Kok Deb:

24 Xb:r Uw meyd seer voorspoedig & gelukkig van een levendige jonge 'twelk de nek en linker schouder aanbod verlost. Verder 'tnodige besorgt en hersteld.

Ten dank Voldaan.

1766. De Heer Johannes Breeser Deb:

15 Xb:r Uw beminde met den onderchirurgijn Ramol gev: met abces onder den arm 'tselve 'sanderendaags geopent verders eenige rijzen geconsul: en gevisit:d—

Komt voor practijk en voor geconsuleerde visitens samen Rds: 3-

Den Inhoud deses Voldaan.

1766. Ernst Philip Sparenberg Deb.

17 Jann. Uw huysvrouw gev: Lab: aan een ongemak uijt een kraam gehouden waar voor 'tnodige besorgt tot ult:mo Maart komt voor practijk visitens en gel: medicam: samen

Rds: 5-

Den Inhoud deses Voldaan.

1766. Joh: Jacob Le Roë Deb.

6 Jann. Uw vrouw met den chirurgijn V: Nierop gev: lab: aande geelsugt—komt voor gedane consultatien tot 12-:

Voldaan met een Vragt Houdt.

1766. P. H. Eksteen, Esq., Deb.

21 Nov. Your beloved very successfully delivered, by means of the method of van Rhoonhuysen, of a living son, whose head had caught fast, without any adversity; the child, however, having died about 18 hours later. Thereafter supplied what was necessary for the lying-in, resulting in complete recovery.

Paid with thanks.

1766. The messenger A. Paling, Deb.

13 Dec. Your servant-girl, who had been a long time in labour, successfully delivered of an awkwardly turned dead child; thereafter supplied what was necessary till complete health was restored.

Paid with thanks.

1766. The widow Michiel de Kok, Deb.

24 Dec. Your servant-girl very successfully and propitiously delivered of a living son, which had proffered its neck and left shoulder. Thereafter supplied what was necessary, and cured.

Paid with thanks.

1766. Mr. Johannes Breaser, Deb.

15 Dec. Visited, together with the under-surgeon Ramol, your beloved, suffering from an abscess under the arm, which we opened the next day; thereafter several visits and consultations:

Comes for treatment, together with visits in consultation Rds. 3
Paid.

1766. Ernst Philip Sparenberg, Deb.

17 Jan. Visited your wife, suffering from an ailment originated out of a child-birth; supplied what was necessary till the end of March; comes for treatment, visits, and medicines Rds. 5

Paid.

1766. Joh. Jac. Le Rôë, Deb.

6 Jan. Visited, together with the surgeon van Nierop, your wife, suffering from jaundice; comes for consultations . 12

Paid by a cart-load of firewood.

I. ON SOUTH AFRICAN PARAMPHISTOMIDAE (Fisch.).

II. SOME TREMATODES IN SOUTH AFRICAN ANURA, AND THE
RELATIONSHIPS AND DISTRIBUTION OF THEIR HOSTS.

By C. S. GROBBELAAR, M.A.,

Lecturer and Demonstrator in the Department of Zoology,
University of Stellenbosch, Stellenbosch, S.A.

(With nine Text-figures.)

I. ON SOUTH AFRICAN PARAMPHISTOMIDAE (Fisch.).

The occurrence of Paramphistomids (=Amphistomes) in sheep and cattle is fairly general in South Africa wherever suitable conditions prevail to ensure its life-history. The conditions required are identical with those required for the life-cycle of the common liver-fluke, viz. swampy vleis where there is a fairly permanent water-supply to ensure both the development of the eggs and the existence of the intermediate host, which in the case of *P. calicophorum* is the ubiquitous *Isidora tropica* Krauss.

These light, flesh-coloured parasites, from 8 to 10 mm. long, occur singly or in groups covering a few square inches in the rumen of sheep and cattle. They attach themselves by the well-developed posterior sucker to the mucous membrane of the rumen between the numerous short villi. The eggs are shed in the stomach, and gradually find their way down the intestine, and are deposited with the faeces. When the faeces with the eggs happen to be dropped in swampy vleis, or in such places where they are immersed under water for some time, development of the eggs proceeds at the advent of the rainy season, and infection of the intermediate host, if present, takes place. The sheep and cattle infect themselves by feeding on the grass or pasture along the margins of pools containing infected snails, and on which the cerceriae have encysted themselves.

In the south-western districts of the Cape Province infection of stock takes place during October, November, and December. In the eastern districts, viz. Molteno, Dordrecht, Barkley East, and wherever Paramphistomids (not necessarily *P. calicophorum*), occur in Natal, Orange Free State, and the Transvaal, infection takes place from April to June.

I had the opportunity of examining a large number of sheep infected with *Paramphistomum calicophorum* and *P. cotylophorum*. In one case I counted as many as 150 individuals in the rumen of an ox, and yet the host seemed none the worse for it, both as regards vitality and condition. Fortunately, therefore, no loss of stock infected with these parasites need be feared.

Paramphistomum calicophorum (Fisch.) (11) (fig. 9) is the species prevailing in the south-western districts of the Cape Province. I also have specimens from Dordrecht, Burghersdorp, and Molteno. It probably occurs all along the lower reaches of the Zumbergen and Drakensbergen into Natal.

Fischöder records it from Queensland, China, and the Cape Province (Kapland).

Paramphistomum cotylophorum (Fisch.) I have found in sheep from Dordrecht, Burghersdorp, and a few specimens were sent me from Onderstepoort.

The Life-history of Paramphistomum calicophorum Fisch.

(See figs. 1-8.)

The commonest fresh-water snail in the Cape Peninsula, and in the districts of Stellenbosch, Paarl, Tulbagh, and Ceres is the ubiquitous *Isidora* (*Physa*) *tropica* (Krauss). The eggs of the previous season, deposited

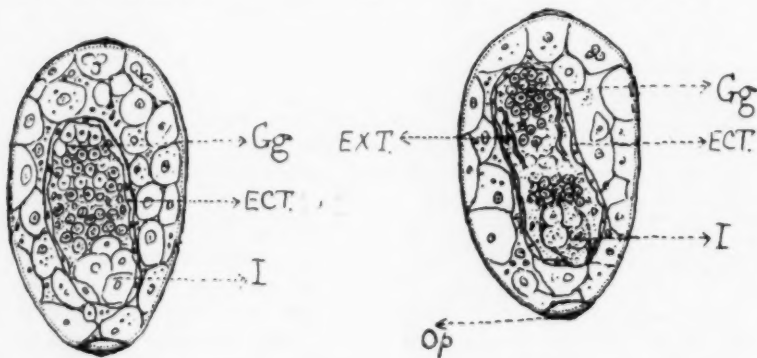


FIG. 1.

FIG. 2.

under the leaves of the common water-lilies (*Aponogeton*) and round the bases of stems of a dwarf variety of rush, hatch in July, in the middle of the rainy season.

During the months of August to November I undertook the examina-

tion of *Isidora tropica* in a restricted locality in what is locally known as the Stellenbosch Flats, situated in the town commonage. From previous observations carried out on the occurrence of rediae and cerceriae in fresh-

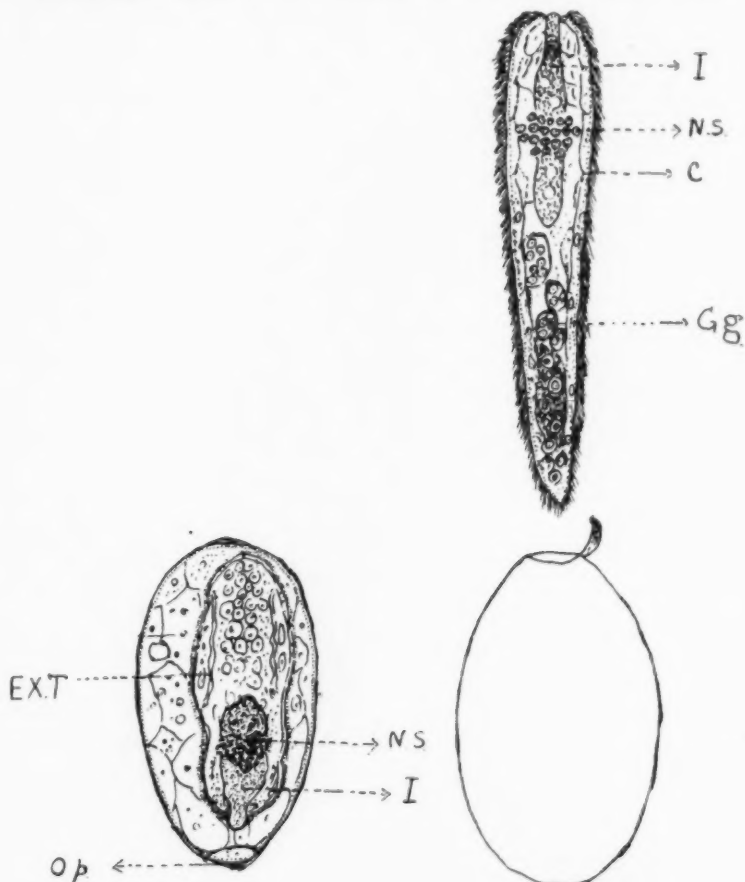


FIG. 3.

FIG. 4.

water snails from that particular locality, I knew that the snails harboured small black cerceriae in abundance. These cerceriae readily encyst on the grass stems growing round and in the pools of water, and thus easily reach the stomach of sheep and cattle that graze on the commonage. Animals that had grazed on the commonage were found to be heavily infected

with Paramphistomids about three months after they had grazed on the infected grass. It needed no particular ingenuity to regard the common *Isidora tropica* as the intermediate host of the locally known Paramphistomid. After a careful examination of the rediae and cerceriae in the

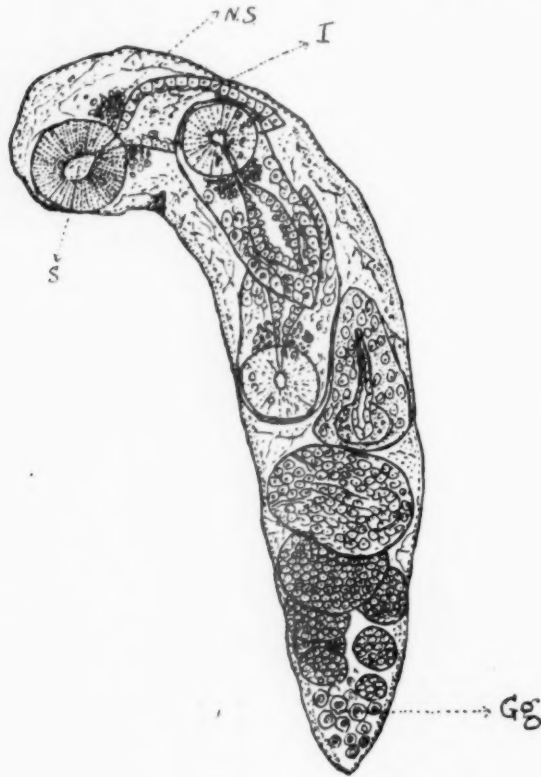


FIG. 5.

intermediate host *Isidora tropica*, I carried out a feeding experiment. Three young sheep and a young lamb were used for the purpose. The sheep were obtained from a dry locality in the Karoo from a small flock I knew to be free of Paramphistomids; the lamb I had reared myself, to make sure that it was free of infection from any source whatsoever. For three weeks, at the rate of two to three feeds per week, they were fed on grass heavily infected with encysted cerceriae. As a result of continued and careful

observations, it was quite certain that the snails from which the cerceriae had escaped to encyst on the grass used in my feeding experiment harboured only these particular dark-coloured cerceriae. In the locality selected there were no other species of fresh-water snails to be found; animal life in the pools, as far as vertebrates are concerned, was confined to the development of tadpoles that died off as soon as the pools began to dry up. The cerceriae encyst very readily, and in the laboratory I caused a large number

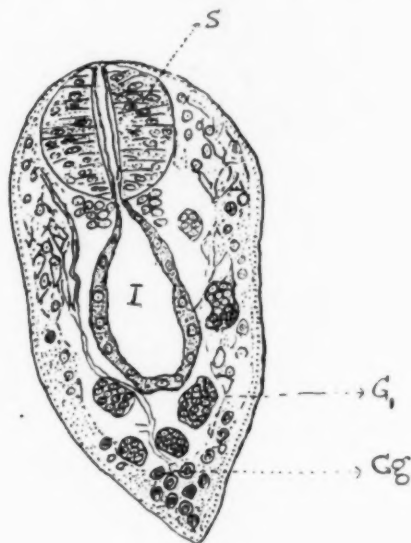


FIG. 6.

to encyst on grass stems placed in a wide tube of water into which the cerceriae of infected snails were removed. Such grass was also used as a feed. I was therefore perfectly sure that my experimental animals were fed only on the cysts of the cerceriae under observation.

A few months after the first feed I found on examination that my experimental animals were heavily infected with Paramphistomids. In some cases these flesh-coloured and cream-coloured parasites were found in all four divisions of the stomach, and a large number had found their way down to the small intestine. The death of one of the young sheep towards the end of the second month was evidently due to a confined life and an abnormal heavy infection which was revealed on a post-mortem examination.

The adult parasite I identified as *Paramphistomum calicophorum*

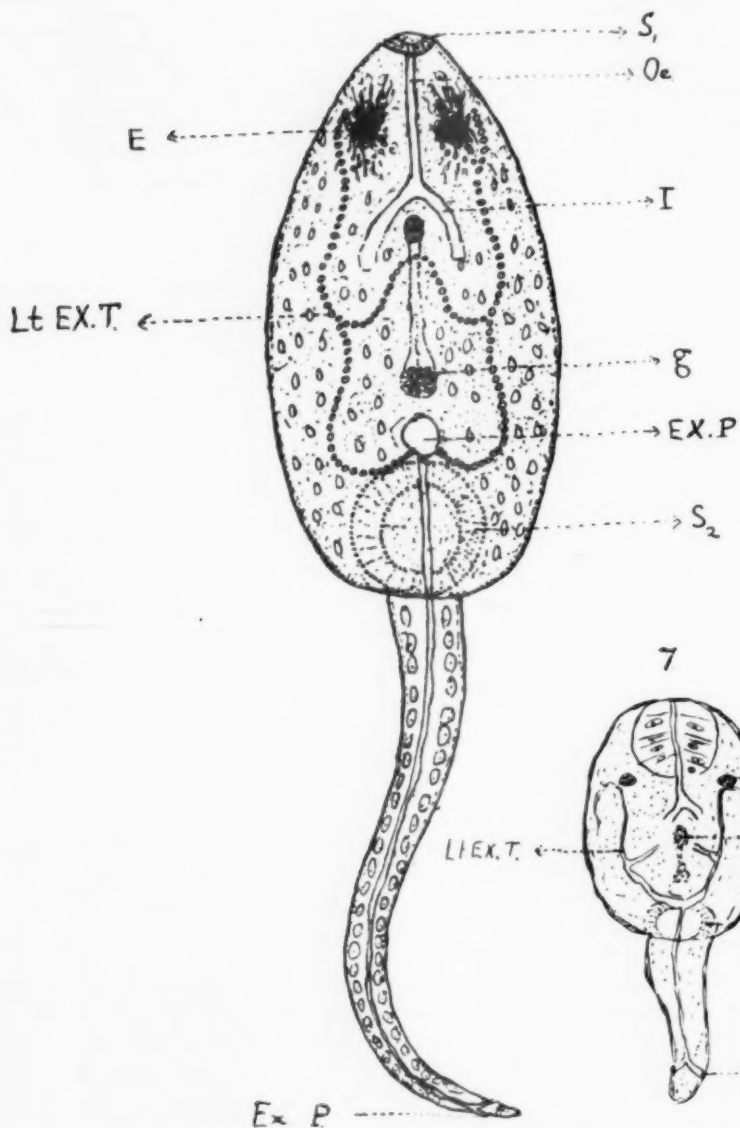


FIG. 8.

FIG. 7.

(Fisch.) (11), and the intermediate host is the small, dark-brown fresh-water snail *Isidora (Physa) tropica*, Krauss.

Observations on the Early Development of the Eggs of
P. calicophorum Fisch.

I collected a number of eggs in a flat dish, filled with water about half an inch deep. The eggs are light yellow, elliptical, tapering a little more

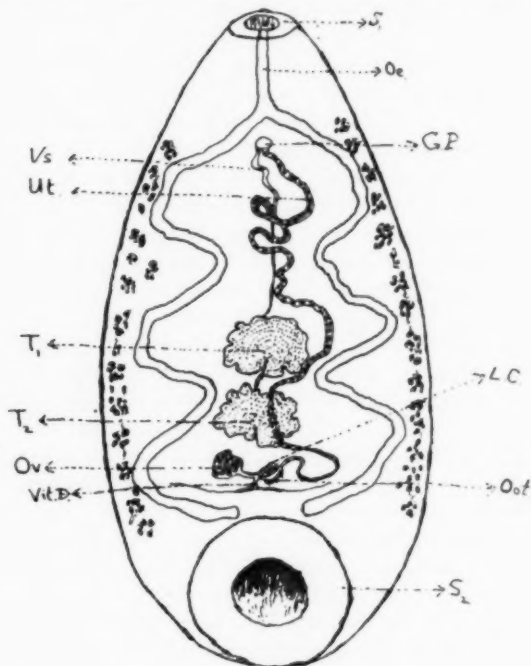


FIG. 9.

towards the opercular pole than to the opposite pole. Length .17 mm., greatest breadth .09 mm. The embryonic cells lie towards the opercular pole, and are surrounded on all sides by yolk-cells. The operculum is small. Development proceeded under water kept at room temperature (16°-17° C.). By segmentation the embryonic cells had on the eighth day extended to the opposite pole; the yolk-cells began to break up and diminish in size. A membrane of thin flattened cells had grown round the entire cell-mass, and one or two large covering cells lay over the anterior extremity of the

embryonic cell-mass. By the fourteenth day the embryo had become quite distinct: the segmentation cells had lost their outline, and the remains of yolk-cells were scattered round the embryo, which now almost filled half of the egg-case and extended from pole to pole.

On the twentieth day the embryo, the future miracidium, began to show slight movements of contraction and subsequent expansion. Evagination and invagination of the future alimentary canal were distinctly seen, accompanied by the ingestion of food-products into the embryonic digestive tract. The digestive tract could be clearly seen, on account of its lumen being filled with coarse granules.

On the twenty-third day the embryo had so much increased in size as to lie with its mouth right up against the operculum. The wriggling movements, the flickering vibration of the cilia, indicated that it had now merely to lift the operculum to emerge from the egg-case as a free-swimming miracidium. As soon as the eggs were now exposed to sunlight, the miracidium burst open the operculum and soon escaped to swim about in a smooth, swift-gliding fashion. It is, of course, well known, from experiments carried out by Leuckart, Thomas, Looss, and others, that sunlight is necessary for the miracidium to finally break through the operculum, and thence swim about freely in search of the intermediate host.

I now introduced a snail into the dish containing the miracidia. At first they swam about aimlessly, but as soon as they happened to come to about half an inch or so from the snail, they suddenly changed their course, swam straight up to the snail, and began to attach themselves to the exposed parts. Some soon let go their hold, swam away, again approached the snail, and attached themselves to it. Others, meantime, crawled over it with the definite object it appeared of entering somewhere. It was apparent that sooner or later some would find their way through the pulmonary aperture into the mantle cavity, encyst themselves round or in the kidney, or work their way up the visceral mass and encyst themselves in the liver.

As Looss (15) had as early, as 1896 completely worked out the life-history of *Paramphistomum cervi* in Egypt, where *Physa alexandrina* (Bourg.) and *Physa micropleura* (Bourg.) are the intermediate hosts, I did not consider it worth while to actually infect snails for the purpose of my investigation. He found (*loc. cit.*, p. 186) that after a period of fifteen days the sac-like sporocysts contain immature rediae, and about fifteen days afterwards the first generation of rediae appear.

The Rediae and Cerceriae.

The rediae are colourless transparent organisms containing daughter-rediae in various stages of development. The more developed daughter-rediae are confined to the anterior region of the parent redia. The birth-

aperture is situated a short distance behind the sucker in the adult rediae. I counted as many as seventeen daughter-rediae in various stages of development in a parent redia. In many there are less. In some rediae one could determine immature from two to three cerceriae with their incipient but clearly defined eye-spots and well-defined tails, together with daughter-rediae; and, as one might expect, the immature cerceriae were confined to the anterior region and the daughter-rediae to the posterior extremity. It seems safe to conclude that the second generation of rediae give rise to rediae only, and the third generation give rise to rediae and cerceriae, and that the fourth and subsequent generations will behave as the third.

With regard to the development and generations of rediae and cerceriae, Looss (*loc. cit.*, p. 189) states in connection with the life-history of *Paramphistomum cervi* :—

“ Les produits de ces rédies commencent à se différencier de très bonne heure; ils prennent naissance et se développent de la même manière que les germes des rédies de l'*Amphistomum subclavatum*. . . . Mais, tandis que chez celui-ci les germes des premières rédies se transforment de suite en cercaires, chez l'*Amphistome conique* (\times *Paramphistomum cervi*) la seconde génération donne encore des rédies. Ces dernières quittent leur mère par un orifice d'accouchement, situé à une courte distance en arrière de la ventouse; elles s'établissent à côté des rédies plus âgées, s'accroissent et produisent une troisième génération qui peut être encore une fois des rédies. De cette manière, il résulte finalement un assez grand nombre de rédies offrant à peu près le même aspect et qui commencent dès lors à produire des cercaires. Chez le ver qui nous occupe je n'ai pas des germes de cercaires en compagnie avec des germes de nouvelles rédies dans une redie mère, comme cela se produit chez le *Gastrodisque*. Mais cela peut être purement accidentel, car je n'ai pu suivre, ainsi je l'ai dit, que pendant dense mois le cycle évolutif de ce ver.”

The mature rediae are .6 mm. to 1 mm. in length. The small anterior sucker is circular, with a diameter of .05–.07 mm. A daughter-redia just before birth is .25 mm. long, and the fairly well-developed sucker .05 mm. in diameter. The sac-like alimentary canal is well defined.

The cerceriae are born in a very immature state. They live for some time in the liver of the intermediate host, and when mature and capable of greater activity they leave the snail. In adult infected snails, as well as uninfected specimens, the shells are worn off at the apex, and a part of the liver is exposed. It is, therefore, certain that the adult cerceriae emerge from the intermediate host through the decaying apex of the shell. They may, of course, also leave the snail by the pulmonary aperture.

As soon as they escape they swim about actively in the water by the rapid wriggling movements of the tail. The body is almost entirely opaque

or black, owing to pronounced superficial pigmentation. This pigment is more pronounced in and round the eye-spots; it then extends forwards and backwards in heavy radiating streaks. In the young immature cerceriae the pigment is confined to the eye-spots a short distance behind the anterior sucker. The body of a mature cerceria is oval, .42 mm. long, and greatest breadth .25 mm. The tail is .5-.6 mm. long. The anterior sucker is small and circular, with a diameter of .03 mm., and the larger posterior ventral sucker has a diameter of .09 mm. The mouth leads into a slightly elongated oesophagus which bifurcates at a point just behind the eye-spots to form the two short limbs of the forked intestine. The tail springs from the dorsal posterior margin of the body just round the exterior margin of the posterior sucker.

The excretory system consists of two lateral trunks. Each main trunk starts anteriorly in the region of the eye-spots, runs downwards and outwards, and suddenly turns inwards. Here each trunk gives off a branch; the branches from each side meet to form a transverse trunk. The main trunks on each side now run outwards and backwards and join just in front of the posterior sucker. At the junction is a well-defined excretory pore, that opens on the dorsal surface. After the two trunks have joined they continue as a single tube down the tail bifurcating just before it reaches the distal extremity to open on each side through two minute pores.

Cystogenous cells are scattered throughout the organism. These cells aggregate to form chains around and along the course of the vascular trunks when the cerceria becomes less active and begins to encyst itself.

The cerceriae readily encyst themselves on the sides of the glass tube in which they may be collected, and on grass stems introduced into the tube. The tail is now cast off, the anterior and posterior extremities are drawn in under the body, and a small round black speck about .2 mm. in diameter is formed. Encystation is accompanied by the expulsion of a granular mass containing small dark rhabdite-like bodies. This granular mass hardens when exposed to the action of sun and air. Before encystation takes place the cerceriae crawl or wriggle up the grass stems for a short distance, and encyst just above the water-level.

I have no hesitation in regarding the cerceriae described above as identical with Cawston's *Cerceria frondosa* (7), which he removed from *Isidora schakoi* Jickeli, from Potchefstroom (Tol.). It is also the same as Gilchrist (13) recorded.

II. SOME TREMATODES IN SOUTH AFRICAN ANURA, AND THE RELATIONSHIPS AND DISTRIBUTION OF THEIR HOSTS.

It is a well-established fact that trematodes, as well as most parasitic worms, occur in fauna groups. If we investigate the trematodes in a particular class of host in a defined zoo-geographical region, we will find that closely allied or similar trematodes probably live in the same class of host in a different zoo-geographical region.

During the last four years I devoted a good deal of time to the examination of frogs in search of trematodes. In view of the cosmopolitan occurrence of the Anura throughout the Union, the present paper deals only with such trematodes as I have from time to time removed from frogs in the neighbourhood of the Cape Peninsula. A search for trematodes in frogs from the more inland districts, viz. Worcester, Middelburg (C.P.), Molteno, and Dordrecht thus far yielded no results. The material, however, which I have collected clearly bear out the truth of the above-mentioned statement.

Methods employed.—In looking for trematodes in frogs, I more or less followed the methods suggested by Johnston (14) and Looss (19). After inspecting the buccal cavity, the ventral body-wall was slit from vent to chin, the digestive tract laid open, and the whole length of the alimentary canal slit open, and the internal surface was examined with an eye-lens. The trematodes found in the body-cavity, gall-bladder, urinary bladder, lungs, etc., were immediately removed to glass dishes containing normal saline. Worms intended for whole mounts were placed in a drop of normal saline on a slide, and covered with a cover-glass or another slide according to the size of the worm. To prevent the cover-glass or the slide being washed away when the fixing fluid is added, it is necessary to put a small weight on the cover-glass or covering slide. The addition of a weight at the same time flattens out the object intended for a whole mount without appreciably changing its length. In the case of larger and stronger worms a good deal of pressure is often necessary to cause the worm to flatten out. In the case of small worms a small glass tube about 8 mm. in diameter and 20 mm. long was used; the pressure can then be regulated by the addition of a little mercury poured into the bottle. For larger and stronger worms small wooden cubes were placed on the upper slide and weights were then placed on these wooden blocks. In view of the action of fixatives on the metal weights, it is necessary to avoid such reactions by first using small wooden or glass cubes, and increase the pressure by adding small metal weights. The whole is now flooded with the fixing solution.

I obtained the best results by using boiling or a hot saturated solution of corrosive sublimate in water with about 5 c.c. of 2 per cent. glacial acetic acid to every 100 c.c. After a few seconds the weights are lifted off for a

moment, and one notices that the fluid has already taken effect by the opacity of the tissues round the edges. The weights are replaced, and finally removed after a period varying from five minutes to half an hour, according to the bulk of the worm.

The worms are further left in the fixing fluid for fifteen minutes and longer. They are subsequently washed in 40-50 per cent. alcohol, left for a day or so in iodised 70 per cent. alcohol, and they are then ready for the after treatment of staining and mounting.

I also obtained very good results by using 10 per cent. formalin as a fixative for whole mounts.

The following trematodes, referred to their systematic position, have been found :—

Order HETEROCOTYLEA Mont.

Family POLYSTOMIDAE Taschbg.

Sub-family POLYSTOMINAE Van Ben.

Genus *Polystomum* Zeder.

1. *Polystomum integerrimum* (Rud.) Fröl.?

In 1758 Roesel von Rosenhof (21) first figured and described this trematode from the urinary bladder of the frog without apparently naming it. In 1792 M. Braun (6) found it in the bladder of the green frog *Rana esculenta* (L.), and described it as *Planaria uniculata*, n. sp.

Zeder (25) in the year 1800 first attempted a classification of the then known trematodes. The various helminthologists had previously often described and figured the same animal under different names. The genus name *Planaria*, to cite one instance, was in turn used to denote entirely different worms. Zeder founded the genus *Polystoma*, and referred the above-mentioned *Polystomum integerrimum* to this genus as *Polystoma ranae*.

Rudolphi (22) was the first to describe and figure it under the name by which we now know it, viz. *Polystomum integerrimum* (he, however, wrote it *Polystoma integerrimum*).

Von Baer and Van Beneden (1827), Stieda and Willemoes-Suhm all subsequently contributed to its anatomy and development. It was, however, left to Zeller (26), who first in 1872 and afterwards in 1876 gave a complete description and fully worked out the life-history of this parasite.

Polystomum integerrimum is found in the urinary bladder of *Xenopus laevis* from Stellenbosch. About 5 per cent. of these frogs, popularly known as "platanas," harbour this parasite. I observed from one to six in the urinary bladder. Curiously enough, I never came across it in a large number of *Rana fuscigula* from Stellenbosch, Paarl, and Worcester.

Order MALACOTYLEA Mont.

Family FASCIOLIDAE Rail.

Sub-family { PLAGIORCHINAE Lühe.
= LEPODERMATINAE Looss.

Genus *Opisthioglyphe* Looss (18).

2. *Opisthioglyphe endoloba* Dujardin.

Frölich (10) included this parasite with *Diplodiscus subclavatus* under the name *Fasciola ranae*. Rudolphi referred Frölich's *Fasciola ranae* to his own *Distomum clavigerum*, and in this was followed by a number of later writers, e.g. Dujardin and Diesing. Dujardin found the real *O. endoloba*, however, and, recognising it as distinct from *D. clavigerum*, described it in 1845 as *Distomum endolobum*. It was subsequently also described by Looss (17).

These small trematodes were found in the posterior region of the intestine, and in the rectum of *Xenopus laevis* from Stellenbosch. They are small oval worms with a body-length of 2-2.55 mm. Anteriorly the body tapers slightly more than posteriorly. The posterior extremity is slightly emarginate. I only came across it once. In about a half-inch length of the intestine, just before it opens into the rectum, I found as many as fifteen individuals.

O. endoloba is the common European frog parasite in *Rana temporaria*, occasionally in *Bufo variabilis*, *calamitas*, and *vulgaris*, and in *Triton cristatus*. The genus renamed by Looss (*loc. cit.*, Zool. Jahrb., p. 588) is closely related to the genera *Dolichosaccus* (Johnston) and *Brachysaccus* (Johnston) found in Australian frogs (14).

Sub-family SYNCOELINAE Looss.

Genus *Halipegus* Looss.

3. *Halipegus ovocaudatus* Vulpian.

Vulpian first records this trematode in 1860. It was subsequently described by Creutzburg (8) and Looss (18). Sonsino (1893) also found it in the stomach and in the anterior region of the intestine, whereas it is usually found in the buccal cavity under the tongue.

From the buccal cavity of *Rana fuscigula*, Stellenbosch.

Family PARAMPHISTOMIDAE Fisch.

Sub-family CLADORCHINAE Fisch.

Genus *Diplodiscus* Diesing.

4. *Diplodiscus subclavatus* Goeze.

Frölich (10) included *Opisthioglyphe endoloba* with *Diplodiscus subclavatus* under the name *Fasciola ranae*. Previously, in 1787, Goeze (12)

described it under the name *Planaria subclavata*. Rudolphi (22) placed it in his own genus *Amphistoma*. Diesing (9) established the genus *Diplodiscus*, and referred *Amphistoma subclavata* to *Diplodiscus*, calling it *Diplodiscus subclavatus*. Later authors—Filippi, 1855; La Valette de St. George, 1855; and Pagenstecker, 1857—devoted themselves to observations on its anatomy and life-history. Von Linstow described the reproductive system fully, and observed the independent movements of the vitellogogenous granules. It was Looss (16), however, who, in 1892, published a complete account of this well-known parasite and fully established its life-history.

Judging from the size of the suckers, length of intestinal limbs and shape of the testes, I found the South African specimens from the rectum of *Xenopus laevis* (Stellenbosch, Paarl, and Kuilsrivier) identical with the European representatives. The Australian representatives constitute the species *D. megalochrus* Johnston and *D. microchrus* Johnston (14).

I wish here to record the discovery of two other trematodes found in *Xenopus laevis*, which I have thus far been unable to refer to their natural position among the Malacotylea. The following is a preliminary account.

*Preliminary Account of a Distomid found in the Gall-bladder
of Xenopus laevis.*

The presence of these worms in the gall-bladder of *Xenopus laevis* imparts a pronounced yellowish-green colour to that organ. On opening up the gall-bladder the worms were found shrouded in a dense mass of a partly coagulated substance. They occur singly or in pairs, more often in pairs. The body, about 7 mm. long, is divided into two distinct regions of more or less equal length: an anterior narrow region .5 mm. wide, and a posterior, flattened, oval region about 2 mm. wide. Posteriorly it ends in a moderately smooth curve. The anterior half is mobile, carrying the anterior and posterior suckers, of which the former has a diameter of .17 mm. and the latter of .1 mm.

It has a well-developed bulbous pharynx, short oesophagus, and intestinal limbs which do not extend to the posterior extremity. The testes are rounded, and placed symmetrically at the same level on each side of the body just within the intestinal limbs in the posterior region of the body. The compact rounded ovary is almost symmetrically placed in front of the testes, slightly to the left of the middle line. The coils of the uterus, filled with yellowish-brown eggs, are confined to the region between and behind the testes, and do not extend over the intestinal limbs on each side. The vitellaria are lateral, extending from the level of the posterior sucker to a point a short distance in front of the termination of the intestinal limbs. They form dendritic clusters arranged on each side external to the intestinal

limbs, and only overlapping the limbs anteriorly. A vesicula seminalis is present. The genital aperture is situated between the suckers, nearer to the posterior sucker.

With respect to such external characters as the division of the body into a narrow mobile anterior and a broad flattened posterior region, it certainly belongs to the Gorgoderinae (cf. *Spathidium folium* v. Olfers), but it differs from them in the presence of a well-developed pharynx, short oesophagus, vitellaria confined to the sides, and a poorly developed posterior sucker.

It differs from the Brachycoelinae in respect to pharynx, length of intestinal limbs, and position of the vitellaria, but agrees with them in respect to the position of ovary and testes and the coils of the uterus confined to the region behind the testes. It certainly shows affinities with both the Gorgoderinae and Brachycoelinae. I am of opinion that it is more closely allied to the latter than to the former.

A Distomid from the Body-cavity of Xenopus laevis belonging to the genus Heterolope Looss (sp. inq.).

This trematode I found in the body-cavity of *Xenopus laevis*. On one occasion I found it under the peritoneum on the outer surface of the lungs. The worm measures 9 mm. from end to end, greatest breadth 2 mm. It tapers more posteriorly than anteriorly. The suckers are well developed, and approach each other. The ovary lies between the testes, which are situated one behind the other in the middle line in the posterior region of the body. Cirrus-sac, ductus ejaculatorius, and cirrus present; a vesicula seminalis lies outside the cirrus-sac. The genital aperture lies just in front of the anterior testes in the posterior region of the body, far behind the posterior sucker. The coils of the uterus lie in front of the testes.

So far I have not been able to find a frog-trematode recorded in which the genital aperture lies far behind the posterior sucker in the posterior region of the body. It undoubtedly belongs to the genus *Heterolope* Looss, or a closely allied genus.

General Conclusions.—In considering the relationships and distribution of the hosts of South African frog-trematodes, one can, it appears to me, only arrive at such conclusions as Johnston (14) did with respect to the Australian frog-trematodes. The following is a reproduction of his conclusions so modified as to include the South African representatives.

The occurrence of the trematodes recorded above from South African frogs gives a striking illustration of the tendency of helminths to occur in faunal groups. That is to say, that helminths found parasitic in any

particular class of host, in a defined zoo-geographical region, find their nearest relatives not in that region in which they themselves occur, but in the same class of host living in other zoo-geographical regions.

Five such faunal groups from Amphibia are now more or less well known, viz. European, North American, Asiatic, Australian, and South African. In each region we find, in hosts of this class, trematodes corresponding or closely corresponding with representatives in the other regions. The group in the European region, as the longest known and most extensively investigated, shows the greatest number of genera; in point of numbers, the American group, to which a good deal of attention has been given of late years by Stafford and others, follows closely on the European. The Australian, Asiatic, and South African groups show smaller numbers, partly, perhaps, because less completely worked up. The facts at present seem to indicate that in Asia, Australia, and South Africa the number of representatives may be further, more or less extensively, added to by subsequent investigations. Besides the frogs, other classes of hosts, as mammals, birds, and reptiles, show faunal groups of parasites with relations analogous to those exhibited by the group from frogs, as the small collection of trematodes I have from mammals thus far go to show, viz. Paramphistomidae and Fasciolidae from sheep and cattle, for example. Leaving the latter in the meantime out of account, and confining ourselves to the groups from frogs, we find: *Opisthoglyphe endoloba*, occurring in the intestine of European and South African frogs, is represented in North America by *Glypthelmius quieta* and in Australia by *Dolichosaccus trypherus* and *Dolichosaccus ischyryus*, which also live in the proximal part of the intestine of their hosts. The three European species of *Pneumonoeces*, found in the lungs, are represented in America by no less than six species (*P. longiplexus* Stafford, *breviplexus* Stafford, *P. varioplexus* Stafford, *P. similiplexus* Stafford, *P. medioplexus* Stafford, and *P. complexus* Seeley), while they are represented in Asia by *Pneumonoeces capyristes* Klein, in Australia by *P. australis*. The only representative of *Pneumonoeces* I have thus far come across was a specimen given me by my chief, Dr. E. J. Goddard; it was removed from the lungs of *Rana fuscigula*. Unfortunately it was damaged, and did not lend itself to specific determination.

The Gorgoderinae, represented in European frogs by the two genera *Gorgodera* and *Gorgoderina*, comprising between them, according to Ssinitzin, five separate species, all living in the bladder of frogs, are represented in America by four species of *Gorgoderina* and one of *Gorgodera*. No species of *Gorgodera* has yet been described from Asia, and thus far I have not yet found any in South Africa, but the genus is represented by one species—*G. australiensis* (Johnston)—from Australia. The European *Brachycoelium crassicolle* R., found in the intestine, is represented in America by *B. hospi-*

tale; in Australia by three species of *Mesocoelium*, viz. *Mesocoelium mesembrinum* (Johnston), *Mesocoelium megaloon* (Johnston), and *Mesocoelium oligoon* (Johnston); in Asia by *M. sociale*; and the form I have preliminarily described from the gall-bladder of *Xenopus laevis* may turn out to be the South African representative of the *Brachycoelinae*.

The *Pleurogenetinae*, occurring in the anterior part of the intestine, are represented in Europe by three genera (*Prosotocus*, *Pleurogenes*, and *Brandesia*), comprising between them seven species; in America by *Loxogenes arcanum*, in Asia by *Pleurogenes gastroporus* and *P. sphaericus*, and in Australia by *P. freycineti* and *P. solus*. *Halipegus ovocaudatus*, occurring in the buccal cavity of European frogs, is also represented in South Africa; in North America represented by *H. occidentalis*; in South America by *H. dubius*; and in Asia by *H. longispina*—all living in similar situations; but, up to the present, no representatives of this fluke have been found in Australia.

Diplodiscus subclavatus in the rectum of European and South African frogs is represented in America by *D. temperatus*, and in Australia by two species of *Diplodiscus*. The European *Polystomum integerrimum* in the bladder of frogs does not seem to be represented in America in frogs, but three species (*P. coronatum* Leidy, *P. hassalli* Goto, and *P. oblongum* R. Wright) occur there in the bladders of Chelonians; in Australia this heterocotylean genus is represented by *Polystomum bulliensi* Johnston, and in South Africa by the European species. No representatives of *Diplodiscus* nor *Polystomum* have yet been described from Asia. The American *Cephalogonimus americanus* in the intestine of frogs may be represented in the Old World by *C. lenoiri* Poir. The genus *Ganeo*, described by Klein from the Indian *Rana hexadactyla*, seems to stand alone, unrepresented in any other region. Likewise the "species inquirenda," belonging to the genus *Heterolope*, from the body-cavity of *Xenopus laevis*, referred to above, seems to be unrepresented in the frogs of other zoo-geographical regions.

It is a remarkable fact that, of the six species of flukes described from frogs inhabiting Southern Asia, four of them appear to find their nearest relatives in flukes from Australian frogs. *Mesocoelium sociale* Lühe is certainly more closely related to the Australian species of *Mesocoelium* than to *Brachycoelium crassicolle* R., its European, or *B. hospitale* Stafford, its American representative. *Pneumonoeces caprystis* Klein has been shown (Johnston, *loc. cit.*, p. 325) to be more nearly related to *P. australis* than to any other European or American species of this genus, and the Asiatic *Pleurogenes gastroporus* and *P. sphaericus* and the Australian *P. freycineti* and *P. solus* have likewise been shown to be more nearly related to one another than any of them are to the American or European *Pleurogenetines*. The South African group, on the other hand, is certainly directly related to

the European frog-flukes, the Asiatic, as it were, standing midway between the Australian and European. The American frog-flukes, many of which have evolved into distinct genera, are not so nearly related in their structure to the European as are the Asiatic. And in addition to this, the American genera, generally speaking, contain more species than the same genera in Asia, Australia, and South Africa, and this may be taken to indicate that the American frogs, with their flukes, have been longer separated from the parent-stock.

The great similarity of the five groups of flukes from frogs found in the five regions mentioned, points to the fact that the flukes are a very old group of animals, and existed in the ancestors of present-day frogs a very long time ago, when their distribution was much less extensive than it is to-day. The mutual relationships of these groups of trematodes support the view that the *Anura* originated somewhere about the centre of the Palearctic region, and migrated westwards, southwards, and south-westwards. They may have reached the western portion of the Boreal land-mass, existing right across from Asia to North America, in early Tertiary times; or they may have made their way westwards in Pliocene times, when a considerable migration of vertebrates westwards is known to have taken place. The Australian forms must have found their way there before the separation of the Australian continent from South-eastern Asia, a separation which is generally supposed to have taken place somewhere about late Cretaceous or Eocene times. The South African forms must have found their way down here during late Pliocene times. The greater diversity of the North American frog-trematodes would seem to indicate that they have been longer separated from the parent-stock than the Asiatic, Australian, and South African forms, so that the America-wards migration probably took place in the earlier of the two periods mentioned.

In view of the probable land connection between Australia and South America through the Antarctic, a connection which is supported by a good deal of biological evidence, it is unfortunate that practically nothing seems to be known about the frog-trematodes of South America. There are only two indirect references to such trematodes, viz. in Braun (2, p. 906) and Klein. A pretty close similarity has, however, been shown by Zschokke to exist between some cestode-parasites of South America and the Australian Marsupials.

The close similarity existing between the respective representatives in the five groups of frog-trematodes in question here reminds us that the trematodes, owing to the conditions under which their lives are passed, have probably evolved much more slowly than their hosts, for the Amphibian ancestors of our own present-day groups, at the time of

their dispersal, must have been considerably different from their representatives now living.

LITERATURE REFERRED TO.

Those papers marked with an asterisk (*) I have not been able to see, but have had to depend for any knowledge of their contents on such works as (1), (2), (17), (18).

- (1) BENHAM.—"The Platyhelminia, Mesozoa, Nemertini," *Lankester's Treatise of Zoology*, pt. iv.
- (2) BRAUN.—"Vermes," in *Bronn's Classen u. Ordnungen des Thierreichs* (1892-3).
- (3) BRAUN.—"Zur Verständigung über die Gultigkeit einiger Namen von Fascioliden-Gattungen," *Zool. Anz.*, xxiv (1901).
- (4) BRAUN.—"Trematoden der Chelonier," *Mitt. a. d. Zool. Mus. in Berlin* (1901).
- (5) BRAUN and LÜHE.—*Handbook of Practical Parasitology*, English edition, 1910.
- * (6) BRAUN, M.—Fortsetzung der Beyträge zur Kenntniss der Eingeweidewürmer (1792).
- (7) CAWSTON, F. G.—"The Cerceriae of the Transvaal," *Parasitology*, vol. xi, No. 1, 1918.
- * (8) CREUTZBURG.—Untersuchungen üb. d. Bau u. d. Entwicklung d. *Dist. Ovocaudatum* Vulpian, etc.
- * (9) DIESING.—"Monographie der Gattungen *Amphistoma* und *Diplodiscus*," *Ann. d. Wiener Mus. der Naturgeschichte*, Wien, 1835.
- * (10) FRÖLICH.—Beyträge zur Naturgeschichte der Eingeweidewürmer (1792).
- (11) FISCHÖDER.—"Die Paramphistomiden der Säugethiere," *Zool. Anz.*, xxiv, Bd. No. 646, 1901.
- * (12) GOEZE.—Versuch. einer Naturgeschichte der Eingeweidewürmer thierischen Körper, Leipzig, 1787.
- (13) GILCHRIST.—"The Life-history of *Distoma luteum*, n. sp., with Notes on some Cerceriae and Rediae found in South Africa," *Parasitology*, vol. x, No. 3, 1918.
- (14) JOHNSTON, S. J.—"On some Trematode Parasites of Australian Frogs," *Proc. of the Linn. Soc., N.S.W.*, vol. xxxvii, No. 146.
- (15) LOOSS, A.—"Recherches sur la Faune Parasitaire de l'Egypte," *Mémoires l'Institut Egyptien*, tome iii, fascicule premier, Le Caire, 1896.
- (16) LOOSS, A.—"Über *Amphistomum subclavatum* Rud.," *Festschrift, Leuckart*, 1892.
- (17) LOOSS, A.—"Die Distomen unserer Fische u. Frösche," *Bibliotheca Zoologica*, Heft 16, 1894.
- (18) LOOSS, A.—"Weitere Beiträge zur Kenntniss der Trematoden-Fauna Ägyptens, u.s.w.," *Zool. Jahrb. Syst.*, xii, pp. 521-784 (1899).
- (19) LOOSS, A.—"Zur Sammel- und Conservierungstechnik von Helminthen," *Zool. Anz.*, xxiv (1901), p. 302.
- * (20) PAGENSTECKER.—Trematodenlarven u. Trematoden, Heidelberg, 1857.
- * (21) ROESEL VON ROSENHOF.—*Historia naturalis ranarum*, etc. (1758).
- * (22) RUDOLPHI.—*Entozoon sive vermium intestinalium historia naturalis* (1809).
- (23) STILES and HASSALL.—"An Inventory of . . . the Fasciolidae," *Archiv de Parasitologie*, i, 1898, p. 81.
- * (24) VULPIAN.—"Note sur un nouveau Distome de la grenouille," *Compte rendu*, 1859.
- * (25) ZEDER.—Erster Nachtrag zur Naturgeschichte der Eingeweidewürmer, etc., Leipzig (1800).
- (26) ZELLER.—"Untersuchungen über die Entwicklung und den Bau des *Polystomum integerrimum*," *Zeit. Wiss. Zool.*, xxii, 1872.

EXPLANATION OF FIGURES.

Figs. 1-4 illustrate the development of the egg up to the hatching of the free-swimming miracidium emerging from the egg-shell.

I. = Intestine.

E.C.T. = External cellular envelope.

Gg. = Germ-cells and yolk-cells.

Ex. T. = Excretory tube.

Op. = Operculum.

N.S. = Cells of nervous system.

C. = Ciliated coat.

S. = Sucker.

G.₁ = Developing mass of germ-cells to give rise to redia.

Fig. 5. A redia of the first generation.

Fig. 6. An immature redia of the second generation.

Fig. 7. An immature cerceria just after it has escaped from the redia.

Fig. 8. A mature free-swimming cerceria, *Cerceria frondosa*.

Fig. 9. Mature *Paramphistomum calicophorum* Fisch.

S.₁ = anterior sucker.

S.₂ = posterior sucker.

Oe.₂ = oesophagus.

Vs.₂ = Terminal region of vas deferens

Ut. = uterus.

T.₁, T.₂ = Testes.

Ov. = Ovary.

Vit. D. = Right vitelline duct from lateral vitelline gland.

Oot. = Ootype.

L.C. = Laurer's canal.

G.P. = Genital aperture.

The figure represents a ventral view with posterior extremity slightly turned up to show posterior sucker.

STUDIES IN THE MORPHOLOGY OF *SELAGINELLA*
PUMILA, SPRING.

PART I.—THE VEGETATIVE ORGANS OF THE SPOROPHYTE.

By A. V. DUTHIE.

(With twenty-six Text-figures.)

With the exception of a doubtful record from Natal, this small annual species of *Selaginella* is known only from the Cape Province. It has been collected in most of the coastal districts from the Cape Peninsula to Alexandria, and has recently been found as far inland as Tulbagh. As the species is inconspicuous and might easily escape the notice of collectors, it is probable that its distribution is more general than is usually supposed. In the Stellenbosch district it occurs abundantly from July to October, and is generally found on clayey soil associated with liverworts and mosses and forming part of the annual flora of flats and hill slopes. It has also been found growing luxuriantly in water-logged turf by the side of trickling water.

So far as I am aware, the only recent work dealing with the species is contained in a paper by Sykes and Stiles (15) which appeared in the *Annals of Botany* in 1910.

The observations embodied in the present paper have extended over several years, and have brought to light certain interesting features, some of which do not appear to have been recorded for other species. The paper deals chiefly with the external morphology and anatomy of the vegetative organs of the sporophyte. A general discussion of the results will be postponed until after the completion of the work.

Selachtendal (10) figured two varieties of *S. pumila*, namely, *pygmaeum* and *bryoides*, differing in size, the latter being the larger and more procumbent. Hieronymus (6) recognises two distinct species under the names *S. pumila*, Schlecht., and *S. bryoides* (Kaulf.), Hieron., the former characterised by lanceolate, the latter by ovate, leaves. The characters upon which the two species or varieties have been based are found, on the examination of material from different parts of the Stellenbosch district, to overlap to

some extent. Specimens gathered in shaded situations on hill slopes are delicate and often more or less procumbent, with ovate leaves; while those gathered on exposed flats are wiry and erect, with lanceolate leaves. Variations in the leaf form may occur in a single specimen, especially if the environment be altered during growth (fig. 1). Two instances of lobed leaves were noted (fig. 2); but these are obviously to be regarded as abnormalities. Individual plants vary greatly in size. Fruiting specimens of 1 cm. are not uncommon, while the tallest plants noted reached the height of 19 cm. By far the greater number are branched; but small unbranched specimens are occasionally met with.

An excellent figure of the leafy stem and cones of the flats type occurs in Marloth's *Flora of South Africa*, vol. i, fig. 60. 1.; while the more



FIG. 1.



FIG. 2.

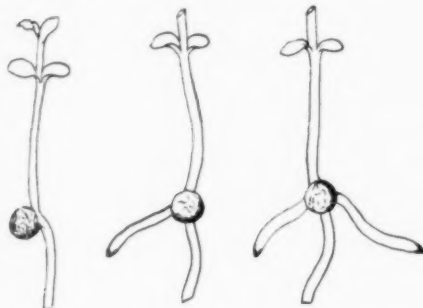


FIG. 3.

delicate hillside type is figured by Sim (14). Neither of these drawings, however, gives a correct impression of the root-system of the plant. As in the majority of described species of *Selaginella* (6), three roots first arise at the base of the hypocotyl in the neighbourhood of the spore, the middle one being the main root of the sporophyte (fig. 3). Each of these roots may branch laterally. The erect and slender hypocotyl, which may reach the height of about 4 mm., bears the two oppositely placed cotyledons and the plumule which is later continued into the leafy stem (fig. 4). Additional erect or sub-erect stems with independent root-systems may arise laterally from the upper part of the hypocotyl.* The first of these secondary stems originates midway between the cotyledons either before or after the appearance of its root-supply (fig. 5, a-d). A second stem with its root may arise at the same level in the neighbourhood of the first, and this process may be repeated until, in hardy specimens, a tufted habit results (fig. 6,

* It is probable that this apparent lateral shoot should be regarded as a delayed branch of the first stem dichotomy, the erect axis representing the produced branch.

a, b). All such secondary axes arise on one side only of the hypocotyl, and their roots grow down through the air for about 2 mm. before striking the soil (fig. 5). Attempts to induce the formation of adventitious roots at other points by means of cuttings or layerings have been unsuccessful. With a little care the secondary stems with their roots can be removed, leaving the primary stem with the cotyledons and trident root-system intact (fig. 7). Both primary and secondary stems may remain unbranched above or produce in one plane a varying number of short lateral branches

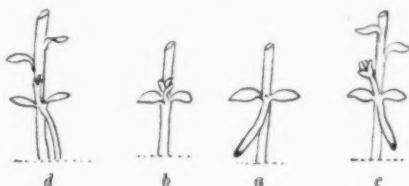


FIG. 5.



FIG. 4.

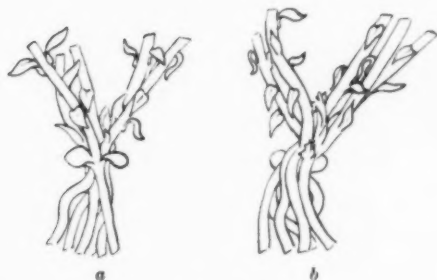


FIG. 6.

each ending in a cone. One or more of the secondary stems may eventually overtop the main stem. The secondary roots may also branch laterally.

The detailed anatomy of the tissues from which these secondary axes and their roots originate, also the minute structure of the growing points of root and stem, will be dealt with in a later paper.

The symmetry of erect and evenly illuminated shoots is radial. The leaves are all of the same size, and are arranged in four vertical rows along the surfaces of the four-sided stem. Though at first sight the phyllotaxy appears to be somewhat irregular, it is found on examination to be a modification of the usual decussate arrangement. The two leaves belonging to each pair do not arise at exactly the same level, and later may become more or less widely separated as the result of the elongation of the intervening

stem tissue (fig. 8). This difference in level may sometimes be observed in the cotyledons themselves. Fig. 9 shows the cotyledons and the succeeding leaf pair cleared in caustic potash. It will be noticed that not only do the leaves of each pair differ in size, but also that the leaf-traces of the two cotyledons are inserted on the stele of the axis at slightly different levels. Decussate leaves are often present at the base of the plant, and may appear at other points as well. In the specimen, a part of which is illustrated in fig. 10, the two opposite cotyledons were followed by four evenly spaced leaves. After these came five approximately decussate leaf pairs, then one whorl of three leaves, and finally eight leaves evenly spaced. Tall-



FIG. 7.



FIG. 8.



FIG. 9.



FIG. 10.

stemmed plants growing in shaded situations often show a considerable interval between the two leaves of a "pair," combined with a certain amount of stem torsion which serves to obscure the phyllotaxy.

While specimens from the flats are usually wiry and erect-stemmed and show typical radial symmetry, the dorsiventral condition is occasionally approximated to, especially in hardy plants where several basal stems form a close, erect tuft. On such stems the leaves appear to be shifted slightly so as to face towards the periphery of the fascicle (fig. 11). Small plants collected in 1918 on sloping ground which had been ploughed over some time before and from which all larger plant growth was absent, showed for the most part erect stems with radial symmetry. Specimens were, however, found in shaded hollows of the uneven soil which exhibited prostrate secondary axes and a marked dorsiventrality. In one of these specimens the leaves on the shaded side were distinctly larger than those on the illuminated side of the stem (figs. 12, 13). This transition from the iso-

phyllous to the anisophyllous condition does not appear to have been observed before in this species.

The root of *S. pumila* is entirely devoid of root hairs. The mycelium of an endophytic fungus was found to be present in all the material examined,



FIG. 11.



FIG. 12.



FIG. 13.

and is especially abundant in the large cells of the inner cortex (figs. 14, 15). It is probable that infection of the root cells takes place through the epidermis, as hyphae are often observed in contact with the outer surface of the root and occasionally in the cavities of the epidermal cells. The hyphae appear to be restricted to the subterranean parts of the root system.

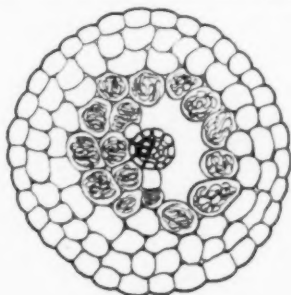


FIG. 14.

The nature of the fungus, its mode of entry into the root and the relationship existing between the two plants, will be dealt with in a later paper. Bruchmann has recorded the presence of an endophytic fungus together with the absence of root hairs for *S. spinulosa* (1) and *S. preissiana* (3), while Janse (6) has reported fungus mycelium in the roots of certain Javanese species of the genus. More recently Uphof (16) has described and figured traces of fungus mycelium in *S. rubella*.

The epidermal cells of the root are somewhat papillate and, as age advances, the outer walls may become markedly thickened. This thicken-

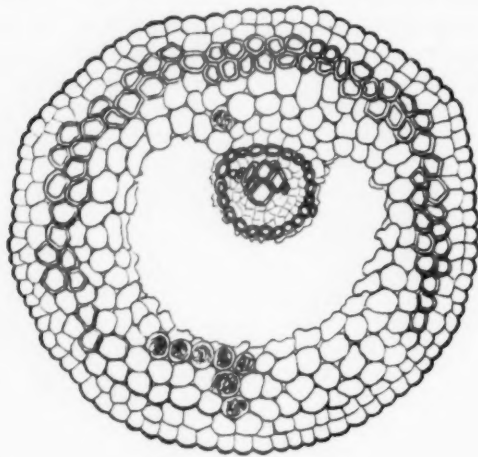


FIG. 15.

ing of the walls may extend to the outer cortex, or (fig. 15) the epidermis and cell layer immediately next to it may remain comparatively thin while a zone of the middle cortex is strongly thickened. Chlorophyll is present

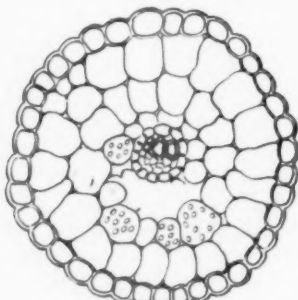


FIG. 16.

in the cortex of the aerial region of the young root (fig. 16). It is worthy of note that in all essential features this aerial part of the root is similar in structure to the subterranean part.

An interesting feature of the root of *S. pumila* which does not appear to have been recorded for any other species of the genus is the presence of

a well-marked air cavity in the inner cortex lying on the phloem side of the stele (figs. 14, 15, 16). This intercellular space arises by the separation and breaking down of some of the inner cortical cells, the remains of which may often be seen still adhering to the endodermis. The resemblance of a transverse section through an old root of *S. pumila*, with its enlarged air cavity and eccentric stele, to that of *Isoetes* (12) or *Stigmaria* (11) is very striking (fig. 15). The resemblance to the latter was found to be still more marked in hardy, tufted plants preserved in formalin alcohol. Here the cavity in the basal region of old roots appeared to have extended right round the endodermis, isolating the central stele completely.

The endodermis of the root is well defined. The cells when young show the usual radial cuticularisation (figs. 14, 16), but later the entire walls

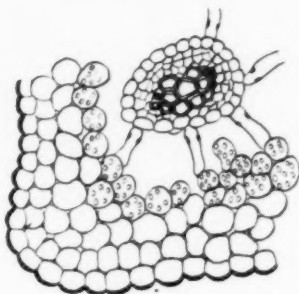


FIG. 17.

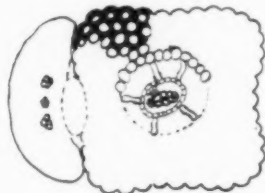


FIG. 18.

become strongly thickened (fig. 15). As in other investigated species of *Selaginella* (5, 16), the root is monarch. In small roots the vascular tissue is poorly developed, the xylem consisting of a small group of from two to five tracheides with the phloem in contact with the metaxylem. In the largest roots examined as many as twelve tracheides were observed, most of them of small size. These small tracheides are sometimes arranged in two groups separated by the larger tracheides. A single layer of pericycle cells appears to be present which may be interrupted by one or more of the tracheides abutting directly on the endodermis.

The stem of *S. pumila* is typically four-sided, with the leaves inserted along the sides (figs. 17, 18). The cells of the epidermal layer are covered by a cuticle and, in young material, the walls are either uniformly lignified or the lignification is confined to the surface walls. In old stems the lignification may extend through the outer cortex, resulting in the formation of a distinct hypodermis. Chlorophyll is specially abundant in the thin-walled cells of the inner cortical layers. Intercellular spaces are present between the cells. The trabeculae which bridge the air space between the inner

cortex and pericycle are of a simple type, each consisting of a much elongated endodermal cell showing the usual cuticular band (figs. 17, 18). The single stele is placed somewhat obliquely in the middle of the air space. The one-layered pericycle is usually separated from the xylem by one or more layers of thin-walled phloem cells. Occasionally a xylem tracheide is found to abut directly upon the endodermis. The stele is usually somewhat elliptical in form, with two protoxylem groups.

Stomata are confined to the margin (fig. 19, *a*) and the aligular surface of the leaf. They occur along the vein, often extending beyond its termination, and may appear also on the two wings. With the exception of the

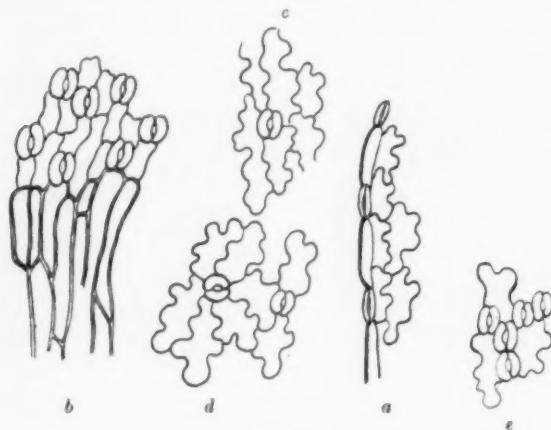


FIG. 19.

cotyledons, a conspicuous leaf-base is present below the insertion of the ligule, and here a definite group of stomata is always found (fig. 19, *b*). Up to twenty stomata have been counted in this region.

The guard cells are placed parallel to the leaf-margin (fig. 19, *c*). Only one instance of a transverse position was noted (fig. 19, *d*). As many as seven epidermal cells may abut upon a single stoma. The number of stomata present may vary within wide limits. When very numerous, adjacent stomata such as those shown in fig. 19, *e*, may occur.

As mentioned above, the leaf-base, except in the cotyledons, is well developed. It contains a mass of aerenchyma roofed over by an epidermis which is perforated by numerous stomata (figs. 19, *b*, 20, 21). Sykes and Stiles (15) describe and figure a similar air cavity in the projecting base of the sporophyll of certain species of *Selaginella*, and compare it with the mucilage cavity of *Lycopodium* and the parichnos of fossil genera. It is

also somewhat suggestive of the aerenchyma in the leaf-base of *Miadesmia* (11). This feature does not appear to have been noted before in the vegetative leaf.

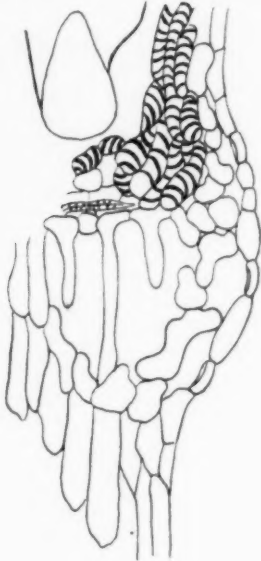


FIG. 20.

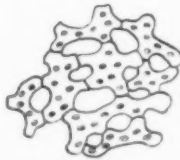


FIG. 21.

The epidermal cells of both surfaces are usually elongated, with sinuous lateral walls (fig. 19). The mesophyll of the leaf-blade shows no differentiation into palisade and spongy parenchyma (fig. 22). It extends right to the leaf-margin.

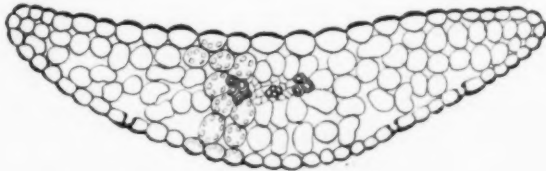


FIG. 22.

The vascular bundle in the cotyledons and lower leaves of the axis is simple, and consists of from four to five rows of delicate spiral and annular tracheides. It does not extend to the apex of the leaf, and, before dying

out, it expands slightly owing to the development of several short, flanking tracheides. The next leaves in order of development are found to possess a more complex vascular tissue. The protoxylem of the vein is accompanied by two more or less interrupted groups of spiral and reticulate transfusion *



FIG. 23.

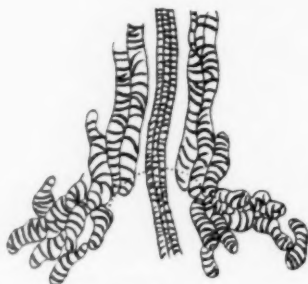


FIG. 24.

tracheides, which may appear at any point between base and apex. All the upper leaves of the plant, including the sporophylls, show two well-developed bands of transfusion tracheides to right and left of the protoxylem (figs. 22, 23, 24). These bands of tracheides do not accompany the leaf-trace into the stem. There is evidently a connection between the amount of transfusion tissue and the number of stomata on the leaf-blade. The only other



FIG. 25.



FIG. 26.

species of *Selaginella* in which a similar triple mid-rib has been noted is *S. laevigata*, Bak., var. *Lyallii*, Spr. (5). Bruchmann in 1909 published an account of the vegetative organs of this species (2), but I have not had the opportunity of consulting his paper, nor yet of obtaining material of the species for comparison with *S. pumila*.

The shape of the ligule was found to vary considerably, as shown in

* The use of this term implies no expression of opinion as to the phylogeny of the tissue in question.

fig. 25. The base is surrounded by a well-developed group of reticulate tracheides which is usually continuous with the transfusion elements already described (figs. 24, 26).

BIBLIOGRAPHY.

- *(1) BRUCHMANN, H.—Untersuchungen über *Selaginella spinulosa*, A. Br., Gotha, 1897.
- *(2) BRUCHMANN, "Von den Vegetationsorganen der *Selaginella Lyallii*," Flora, 1909.
- *(3) BRUCHMANN, "*Selaginella preissiana*," Flora, 1910.
(Review of this paper in Bot. Gaz., 49, 399.)
- (4) GOEBEL, K.—Organography of Plants.
- (5) HARVEY-GIBSON, R. J.—"Contributions towards a Knowledge of the Anatomy of the Genus *Selaginella*, Spr."
Part 1. "The Stem," Ann. Bot., 8, 1894.
Part 2. "The Ligule," Ann. Bot., 10, 1896.
Part 3. "The Leaf," Ann. Bot., 11, 1897.
Part 4. "The Root," Ann. Bot., 16, 1902.
- (6) HIERONYMUS.—Naturliche Pflanzen Familien., 1902.
- (7) HILL, T. G.—"On the Presence of Parichnos in Recent Plants," Ann. Bot., 20.
- (8) LOTSY, J. P.—Vorträge über Botanische Stammesgeschichte.
- (9) MARLOTH.—Flora of South Africa, Vol. I.
- (10) SCLECHTENDAL.—Adumbriationes Plantarum, 1825.
- (11) SCOTT, D. H.—Studies in Fossil Botany, Part I.
- (12) SCOTT, D. H., and T. G. HILL.—"The Structure of *Isoetes Hystriz*," Ann. Bot., 14.
- (13) SEWARD, A. C.—Fossil Plants, Vol. II.
- (14) SIM, T. R.—Ferns of South Africa, 1915.
- (15) SYKES, M. G., and W. STILES.—"The Cones of the Genus *Selaginella*," Ann. Bot., 1910.
- (16) UPHOF, J. C. TH.—"Contributions towards a Knowledge of the Anatomy of the Genus *Selaginella*: The Root," Ann. Bot., 34, 1920.

EXPLANATION OF FIGURES.

- Fig. 1. Variations in leaf form; from one plant.
- Fig. 2. Abnormal leaf forms.
- Fig. 3. Development of first roots at base of hypocotyl of sporcling.
- Fig. 4. Plant with unbranched stem and three roots at base of hypocotyl.
- Fig. 5, a-d. Development of first secondary axis with its root, midway between bases of cotyledons.
- Fig. 6. Plant with five secondary axes developed at base. a. Hypocotyl shown.
- b. Reverse of fig. a.
- Fig. 7, b. Group of secondary axes removed from primary axis a.
- Fig. 8. Part of radially symmetric stem with four leaf rows.
- Fig. 9. Cotyledons and succeeding leaf-pair cleared in caustic potash.
- Fig. 10. Part of stem with three leaf-pairs, one whorl of three leaves, and two alternate leaves.

* I have had no opportunity of consulting papers (1) to (3).

Fig. 11. Part of stem of unequally illuminated plant showing approach to dorsiventral condition.

Fig. 12. Unequally illuminated plant with two prostrate secondary axes showing dorsiventrality and anisophylly.

Fig. 13. Secondary axis of 12, on a larger scale, showing difference in size of dorsal and ventral leaves.

Fig. 14. Transverse section of young root showing endophytic fungus and cortical cavity.

Fig. 15. Transverse section of old root.

Fig. 16. Transverse section through aerial part of young root of secondary axis.

Fig. 17. Part of transverse section of young stem.

Fig. 18. Section of older stem with base of leaf and ligule.

Fig. 19. *a.* Part of leaf-margin with stomata. *b.* Part of epidermis of leaf-base with stomata abutting upon thickened epidermis of stem destitute of stomata. *c.* Stoma with neighbouring epidermal cells elongated in direction of leaf-margin. *d.* Normally placed stoma and stoma with guard cells transverse to long axis of leaf.

Fig. 20. Vertical section through leaf-base showing aerenchyma, stomata, and tracheides at base of ligule. The leaf-trace is cut obliquely.

Fig. 21. Horizontal section through superficial aerenchyma of leaf-base.

Fig. 22. Transverse section across leaf-blade.

Fig. 23. Outline of leaf showing triple vein, position of ligule, and of stomatal area of leaf-base.

Fig. 24. Part of leaf cleared in caustic potash showing the protoxylem and two parallel bands of transfusion tracheides continuous with reticulate tracheides at base of ligule.

Fig. 25. Variations in shape of ligule. The glossopodial cells are not shown.

Fig. 26. Transverse section through base of ligule showing tracheal sheath.

SOME OBSERVATIONS ON THE EFFECTS OF A BUSH
FIRE ON THE VEGETATION OF SIGNAL HILL.

By MARGARET R. MICHELL,

Lecturer in Botany, University of Cape Town.

(With Plates X to XII and one Text-figure.)

The practice of burning the veld in South Africa is probably an ancient one. According to Dr. Marloth (3), the early Portuguese navigators saw bush fires while sailing along the coast of the Cape Province, thus indicating that the custom was not one introduced by the early white settlers.

At the present time there is no exact information as to the effects that this periodic burning has on the vegetation, though certain experiments in connection with this problem are being conducted at Pretoria by Dr. E. P. Phillips of the Division of Botany (5, 6). In South Africa, however, the problem is not a uniform one, as the types of vegetation to be found in different parts of the Union show fundamental differences. Thus the area which Dr. Phillips has under observation is typical grassland, such as covers large tracts of country in the Transvaal and Orange Free State, while the area with which the present paper is concerned is normally covered with sclerophyllous bush, the characteristic vegetation of the south-western region. In regions of grassland, as a rule, burning is carried out systematically, year by year, whereas in the south-western districts this is not the case, fires occurring at irregular intervals. These latter fires may be due to natural causes, but more often they are started deliberately either by the farmer who wants young shoots on which to graze his cattle, or by the poorer members of the population who, after some time has elapsed, collect the dead branches for firewood. It follows from the nature of the vegetation that in grassland the fires are more readily controlled than in the bush-covered country of the south-west.

Signal Hill, or Lion Mountain, on a portion of whose slopes the following investigation was carried out, separates Cape Town from the sea on its western side. As will be seen from the accompanying map (fig. 1), the hill runs in a north-north-easterly direction, the highest point (about 2200 feet),

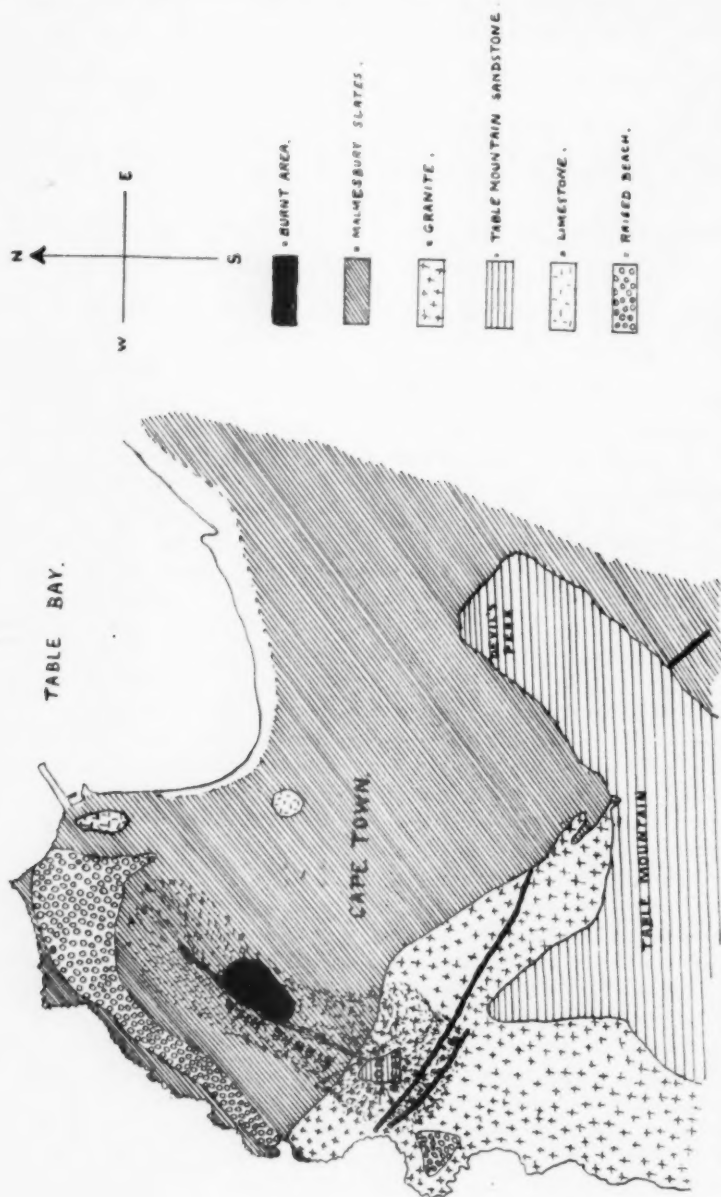


FIG. 1.—Geological map of the northern part of the Cape Peninsula, showing Signal Hill and the burnt area. Adapted from the Geological map of the Cape Division, 1899. Scale $1\frac{1}{4}$ inch to a mile.

known as Lion's Head, being situated at the southern end of the hill. The rest of the hill consists of a ridge about a mile and a half long and of considerably lower altitude than the head, the average height being about 1100 feet.

The soil of that part of Signal Hill with which this paper is directly concerned is clay, derived from the Malmesbury slates, of which the northern end of the hill is composed. The burnt area is by no means uniform in character. Several valleys (fig. 2) of more or less equal depth cut up the hillside, and these have a vegetation which in its constituents shows certain marked differences from that of the ridges in between the valleys.

The bush fire, the effects of which are recorded in this paper, broke out on the 5th February 1919, and owing to a strong south-east wind it was not extinguished till late on the following day. The approximate extent of the burnt area is shown in fig. 1. Owing to the somewhat sheltered position of the water-course in each valley, the vegetation there was not badly burnt, while elsewhere the fire killed the aerial parts of every plant with the exception of a few isolated pines and one eucalyptus tree. These trees were the only ones on the burnt slope, and they were odd specimens which had invaded the area from neighbouring plantations.

At one spot at the southern end of the area the ground is fenced off, and this protected area was valuable in affording a means of judging the effects of cattle and man on the regenerative processes after the fire.

In our * investigations valley A (fig. 2) and its immediate slopes provided us with a suitably restricted field for more detailed observations. The other parts of the burnt area were visited from time to time, but an intensive study was made of valley A alone.

Detailed observations on the vegetation of this part of Signal Hill were not made prior to the bush fire, and consequently it was necessary to rely upon the evidence of charred bushes, and the character of a few small patches which had escaped the fire, in estimating the original composition of the flora. The plant which dominated these slopes as seen from the town was *Rhus lucida*, bushes of which were dotted at frequent intervals over this part of the hill. The green colour of these bushes was in marked contrast with the prevailing grey-green colour of the smaller shrubs growing in between the *Rhus* bushes.

The first visit to the burnt area was made eighteen days after the fire, and during that interval there had been some rainy days interspersed with fine, hot days.

* During the year 1919 this work was carried out in conjunction with three students—Miss S. Garabedian, Miss E. G. Torrance, and Miss W. Wilson. The investigation formed part of the work of the M.A. course in botany for that year.

The following shrubs were noted on a small unburnt area at the foot of valley A :—

Rhus lucida (a).†
Elytropappus Rhinocerotis (a).
Cliffortia ruscifolia (f).
Passerina sp. (f).
Athanasia trifurcata (f).
Leyssera gnaphaloides (f).
Asparagus capensis (f).
Psoralea hirta (f).
Noltea africana (l, f).
Rhus glauca (o).
Rhus angustifolia (o).
Passerina filiformis (o).
Anthospermum ciliare (o).
Borbonia cordata (o).
Solanum sodomaeum (o).
Berkheya rigida (o).
Aster fruticosa (o).
Cliffortia polygonifolia (o).
Euclea racemosa (o).
Gymnosporia buxifolia (o). In water-course only.
Leonotis Leonurus (o). " "
Conyza ivifolia (r). " "

In addition the following undershrubs or herbs were found :—

Cynodon Dactylon (l, a).
 * *Lobelia Erinus* (l, a).
Selago adpressa (l, f).
Chironia baccata (o).
Pelargonium grossularioides (o).
Rumex acetosella (o).
 * *Erodium malachoides* (o).
Andropogon hirtus (o).
Briza maxima (o).
Helichrysum crispum (o).
Helichrysum cymosum (o).
Scabiosa columbaria (o).
Oenanthe filiformis (o).

† The usual abbreviations have been used. a=abundant, f=frequent, o=occasional, r=rare, l=locally.

Gorteria personata (o).

Pellaea auriculata (o).

* *Lobelia lutea* (r).

(* indicates that the plants were in flower.)

In one spot an outcrop of slate was seen, and this was covered with crustaceous lichens. Associated with this rock were *Mesembryanthemum asperum* and *Crassula muricata*, both succulents, and it may be noted here that apart from these rock exposures succulents were rare.

The outstanding feature of this first visit was the vigorous growth of aerial shoots in *Asparagus capensis* and *Andropogon hirtus*. Both these species had been burnt down to the ground; but in spite of the fact that less than three weeks had elapsed since the fire, the whole hillside was dotted with these plants, their green colour being in vivid contrast with the prevailing blackness of the scene. In the case of *Asparagus capensis* many bushes were a foot and a half high. Both these species were more abundant on the southern slopes of each valley than elsewhere, and it was noted later that these slopes which are more exposed to sunlight than the northern slopes bear a more open type of vegetation. Another plant which was growing actively on the burnt area was *Hibiscus aethiopicus*, but owing to its small size it did not strike a conspicuous note, as was the case with the two other species.

The next visit was paid about a month later, on the 20th March. The condition of the area was little changed. One plant of *Asparagus capensis* was in full flower, and it is of interest to note that the usual flowering period of this species (May to June) had been anticipated. *Hibiscus aethiopicus* was in flower all over the area. Besides these, *Gladiolus brevifolius* and *Haemanthus coccineus* were flowering, the latter being very conspicuous. In the following years (1920 and 1921) flowers of this plant were rarely found, and it seems safe to conclude that the fire must have induced the burst of activity in 1919.

All over the hillside young shoots were being given off in profusion from the bases of the charred stems in the various species of *Rhus* which characterise these slopes. The following species were noted :—

Rhus lucida (a).

R. angustifolia (l, f).

R. glauca (o).

R. tomentosa (o).

R. mucronata (o).

R. rosmarinifolia (r).

Other plants here and there were seen to be behaving in a similar fashion,

but the phenomenon was not as general in these as amongst the species of *Rhus*. The following list of such plants was made :—

- Montinia acris (l, f).
- Zantedeschia aethiopica (o).
- Sonchus Ecklonianus (o).
- Cliffortia polygonifolia (o).
- Salvia africana (o).
- Anthospermum ciliare (o).
- Athanasia trifurcata (o).
- Mohria caffrorum (o).
- Leonotis Leonurus (r).
- Bobartia spathacea (r).
- Peucedanum galbanum (r).

Gymnosporia buxifolia was giving off new shoots, but as the plants were confined to the water-courses they had been somewhat protected and the aerial shoots had not been killed. A common plant in the water-course at the foot of valley B was *Clutya pulchella*, and although the old stems appeared badly charred, they were giving off new shoots over the whole surface. This was an unusual method of regeneration, the only other plant behaving in a similar way being a young *Eucalyptus* tree which was growing on the slopes above valley C.

A week later another visit was paid, and the only change noted was that certain plants were now in flower, viz. *Curculigo plicata*, *Oenanthe filiformis*, *Andropogon hirtus*, and *Oxalis livida*. The two first-mentioned species belong to the same class of plant as *Haemanthus coccineus*, the flowers in all cases appearing some considerable time before the leaves.

In the Cape Peninsula there are two marked periods of flowering activity. The first begins about the end of March and attains its maximum with the first winter rains. Numerous species of *Oxalis* are characteristic plants of this period. The second and major period is in the spring, towards the end of the rainy season. These two flowering periods are well marked on the area under discussion, and it is noteworthy that in general there was no obvious forestalling of the periods in 1919. However, though the times of flowering remained as in normal years, the same cannot be said of the quantity and quality of the flowers produced. In both these respects the flowers on the burnt area were far above the average, and this in a year when elsewhere the flowers were not particularly fine.

During April the following plants came into flower :—

- Oxalis tomentosa* (a). On the lower slopes only.
- Oxalis variabilis* (a). Slightly later than *O. tomentosa*.

- Oxalis hirta* (f).
- Oxalis sericea* (o).
- Melica racemosa* (o).
- Polygonum atraphaxoides* (o).

All the species of *Oxalis* which were found on the burnt area have deeply situated bulbs, and several new bulbs are formed each year, vegetative reproduction seeming to be the rule. As a result, the ground is covered with *Oxalis* plants and the whole hillside presents an extremely gay appearance. In 1919 the brilliant display of *Oxalis* was noteworthy.

In April the following additions were made to the March list of plants which were producing new shoots from the uninjured parts below :—

- Adiantopsis capensis* (a). Under bushes and on northern slopes of valleys.
- Pellaea auriculata* (f). " " "
- Cliffortia ruscifolia* (o).
- Royena glabra* (o).
- Bulbine favosa* (o). Valley only.
- Kiggelaria africana* (r). " "
- Lycium afrum* (r).

It was noted at this time that certain plants showed no signs of recovery after the fire, notably *Elytropappus Rhinocerotis*, and *Protea mellifera*, which was represented by a single specimen.

The winter rains began to fall in May, and on the next visit on the 13th June many changes were noted.

In the winter the northern side of each valley gets very little sun, and the differences in vegetation between the two sides of each valley were very marked. Valley A bore evidences of a great rush of water during the rains which had fallen shortly before this visit, and the stream bed was characterised by a large number of young shoots of *Ranunculus*. Later in the year two species were identified, *R. pubescens* and *R. muricatus*. On the banks at the side of the water-course and also on the northern slopes of the valley an abundance of small ferns, mosses, liverworts, and lichens were noted. The most abundant fern was *Adiantopsis capensis*, which here and there formed close sward-like patches. *Pellaea auriculata* and *Mohria caffrorum* were plentiful. The following genera of liverworts were noted : *Fossombronia*, *Fimbriaria*, *Lunularia*, and *Riccia*. The mosses and lichens were not identified. The latter were confined to the exposed rock surfaces and branches of various shrubs. The following herbaceous plants, all of which possess underground organs of perennation, were noted on the northern slope :—

- * *Crassula septas* (a).
- * *Rumex cordatus* (f).

- Scabiosa columbaria (f).
- Cyphia Phyteuma (f).
- * Oxalis variabilis (f).
- * Oxalis glabra (f).
- * Oxalis lanata (f).
- Oxalis tomentosa (f). Flowers dead.
- * Oxalis cernua (o).
- * Oxalis compressa (o).
- * Oxalis sericea (o).
- * Curculigo plicata (o).
- Rumex sp. (o).
- * Crassula saxifraga (o).

These plants covered the ground, and gave an air of luxuriant growth which was entirely lacking in the case of the southern slope. On the latter the cryptogamic element was poorly represented, and *Crassula septas*, which owing to its beautiful clusters of white flowers was most conspicuous on the northern side, was entirely absent. *Rumex cordata* and *Scabiosa columbaria* were also lacking on this side. The various species of *Oxalis*, however, were well represented, and in addition *Curculigo plicata*, which was at this time in leaf, though in many cases the flowers were still persisting. *Asparagus capensis* was flowering freely.

On both slopes of the valley, and also on the ridge between valleys A and B, the leaves of a large number of Monocotyledons were seen.

On the ridge seedlings of *Borbonia cordata* were common, and were localised in a number of "schools." This was the first example of a plant coming up from seed after the fire. The normal fruiting period of this species coincided with the time of the fire, and it seems safe to conclude that the seeds, which are fairly large and heavy and thus not wind distributed, are able to withstand a high degree of heat.

Several plants of *Antholyza revoluta* were seen in flower on the ridge. Plants of *Arctopus echinatus* were also fairly common.

Valley B was visited on this occasion, and was found to agree fairly closely with A, both in the composition of the flora and the distribution of species.

The whole area, with the exception of the portion enclosed by the fence already mentioned, was used as a grazing-ground for cattle. The result of this was twofold. Certain plants, notably *Andropogon hirtus*, were almost entirely eaten down. Inside the fence, on the other hand, the tall inflorescences of this grass were quite a feature of the vegetation (fig. 3). A second result of the cattle grazing was the formation of a number of tracks all over the hillside and the consequent loosening of soil. This was very

conspicuous on the ridge at the northern boundary of the burnt area. Here several new water-courses were formed as a result of the washing away of the loosened soil.

Man was also instrumental in loosening the soil. Wood-gatherers were constantly seen, as is always the case after a bush fire, and the tracks caused by dragging large bundles of burnt brushwood down the hill were very noticeable.

The outstanding feature of the next period of activity, which began towards the end of August, was the predominance of Monocotyledons amongst the herbaceous plants in flower. The following were noted :—

MONOCOTYLEDONS.

Water-course of valley A.

- Moraea tristis (f).
- Moraea papilionacea (o).

Valley slopes and ridge.

- Sparaxis grandiflora (a).
- Geissorhiza secunda (a).
- Geissorhiza sp. (a).
- Pterygodium catholicum (a).
- Homeria collina (f).
- Moraea tripetala (f).
- Lachenalia orchioidea (f). Not in full flower.
- Pterygodium alatum (f).
- Disperis villosa (l, f).
- Hesperantha sp. (o).
- Babiana plicata (o). End of flowering period.
- Satyrium bicornis (o).
- Hypoxis serrata (o).
- Romulea chloroleuca (o).
- Lachenalia unifolia (r).
- Gladiolus gracilis (r).
- Disperis circumflexa (r).

Ridge only.

- Romulea hirsuta (a).
- Baeometra collumellaris (f).
- Galaxia ovata (o).
- Ornithogalum tenellum (o).
- Aristea cyanea (o).
- Galaxia graminea (r).

*Northern slopes of valley A.**Hypoxis stellata* (f).*Southern slopes of valley A.**Babiana stricta* (f).

DICOTYLEDONS.

*Valley slopes and ridge.**Dimorphotheca pluvialis* (f).*Drosera cistiflora* (f).*Diascia* sp. (f).*Cenia turbinata* (o).*Oxalis cernua* (o).*Tripteris clandestina* (o).*Zantedeschia aethiopica* (o).*Oxalis variabilis* (o).*Anagallis arvensis* (o).*Nemesia barbata* (o).*Nemesia parviflora* (o).*Zaluzianskya divaricata* (o).*Oxalis sericea* (o).*Oxalis compressa* (o).*Silene Burchellii* (o).*Cerastium capense* (o).*Heliophila diffusa* (o).*Adenogramma galioides* (o).*Cyphia volubilis* (r).*Microlooma lineare* (r).*Northern slopes of valley A.**Scabiosa columbaria* (f).*Southern slopes of valley A.*

Ursinia anthemoides (f). This plant was also found in small numbers on other parts of the area.

Gazania pinnata (o).

With regard to the vertical range of these plants, the majority gradually diminished in numbers towards the top of the area. There were a few exceptions to this general rule. *Hypoxis serrata* was present on the higher slopes only. *Oxalis cernua*, which was present on the lower slopes of the area, was replaced towards the top by the closely related species *Oxalis sericea*. The orchids, with the exception of *Pterygodium catholicum*, were all confined to the lower slopes.

Towards the end of October a further visit was paid, and most of the plants that had been noted in September were found to have finished flowering. Other plants had taken their place, the most conspicuous of these being *Moraea pavonia* var. *lutea*. This plant was abundant on the lower slopes of the burnt area, and the tall stems tipped with comparatively small yellow flowers provided the dominant note in the vegetation. On a more detailed survey of the area it was found that a large number of grasses were in flower, and these together with *Moraea pavonia* may be said to characterise the late spring period. The following list of grasses was made :—

Vulpia bromoides (a).
Lasiochloa ciliaris (a).
Aira caryophyllea (o).
Briza major (a).
Melica racemosa (f).
Ehrharta calycina (f).
Festuca scabra (f).
Andropogon hirtus (f).
Bromus molliformis (l, f).
Briza minor (o).
Ehrharta erecta (o).
Lolium rigidum (o).
Avena barbata (o).
Brizopyrum capense (o).
Bromus unioloides (o).
Hordeum murinum (o).
Aristida angustata (r).

These grasses were widely distributed over the lower slopes of the whole area.

In addition to the grasses, the following plants were noted as being in flower :—

Water-course of valley A.

Lobelia Erinus (f).
Ranunculus pubescens (f).
Ranunculus muricatus (f).
Caucalis africana (f).

Valley slopes and ridge.

Moraea pavonia var. *lutea* (a).
Trifolium angustifolium (a).
Rhus lucida (a).

Passerina sp. (f).
Psoralea decumbens (f).
Leyssera gnaphaloides (f).
Felicia tenella (f).
Sebaea aurea (white variety) (f).
Pelargonium tabulare (f).
Medicago denticulata (l, f).
Trifolium agrarium (l, f).
Trifolium procumbens (l, f).
Trifolium glomeratum (l, f).
Geranium dissectum (o).
Chrysocoma coma-aurea (o).
Sebaea exacoides (o).
Pelargonium grossularoides (o).
Pelargonium myrrhifolium (o).
Wahlenbergia capensis (o).
Prismatocarpus sessilis (o).
Lessertia tomentosa (o).
Hibiscus aethiopicus (o).
Gorteria personata (o).
Euphorbia genistoides (o).
Fumaria muralis (r).
Pelargonium lobatum (r).
Disa micrantha (r).

Northern slopes of valley A.

Cyphia Phyteuma (f).

Southern slopes of valley A.

Aster fruticosa (l, a).
Solanum sodomaeum (o).

The following were seen coming into flower, but were not fully out :—

Micranthus plantagineus (f).
Cyanella capensis (f).
Psoralea hirta (l, f).
Micranthus fistulosus (o).

As the above list indicates, there were a large number of plants in flower at this time, but the general effect was not as showy as that of the previous month. The differences between the northern and southern slopes of the valleys were less marked than before, and it is noteworthy that at this time

of year the sun's rays fall much more uniformly on the two slopes than during the winter months.

The whole area showed a deficiency in annuals, and certain of these had clearly been introduced by cattle since the fire. Amongst these were noted *Trifolium agrarium*, *Trifolium procumbens*, *Trifolium glomeratum*, and *Medicago denticulata*, which were found associated with animal manure.

The foregoing concludes the observations made during the year immediately following the fire. In 1920 the first visit took place on the 4th April. The earlier months of this year had been very dry, and the hillside presented a very barren appearance. On this occasion the characteristic feature was the bright green of the bushes of *Rhus lucida*, this shrub having grown very actively during the winter months of the previous year. The average height of the bushes was about three feet. The ground in between the bushes was occupied by a large number of smaller plants of a grey-green colour. A careful examination was made, and a large number of them were found to be seedlings. The following list of seedlings was made:—

- Elytropappus Rhinocerotis (a).
- † Athanasia trifurcata (l, a).
- Psoralea hirta (l, a).
- Borbonia cordata (l, a).
- Arthrosolen laxus (f).
- † Anthospermum ciliare (f).
- Psoralea uncinata (l, f).
- † Peucedanum galbanum (l, f).
- Erica viridi-purpurea (l, f).
- Mesembryanthemum scabrum (o).
- Cliffortia ruscifolia (o).
- † Cliffortia polygonifolia (o).
- Conyza ambigua (o). Chiefly growing in bushes
of *Rhus lucida*.
- † Aster fruticosa (o).
- Aspalathus spinosa (o).
- Aspalathus sp. (possibly *A. thymifolia*), (o).
- Senecio rigida (o). Mostly confined to the damper
parts of the area.
- Senecio pubigerus (o). Chiefly growing in bushes
of *Rhus lucida*.
- Senecio Burchellii (o). " " "
- Euryops abrotanifolius (o).
- Passerina sp. (o).
- Osteospermum moniliferum (o).

- Stoebe alopecuroides* (o).
 † *Salvia africana* (r).
 † *Olea verrucosa* (r).
Hakea suavolens (o). Very local.

The outstanding feature is the large number of representatives of the families Compositae and Leguminosae (fig. 4). It is illuminating to compare this list with the following, which contains the names of all the shrubs which had rejuvenated from underground stocks:—

- Rhus lucida* (a).
Asparagus capensis (f).
Rhus angustifolia (l, f).
Myrsine africana (l, f).
Montinia acris (l, f).
Rhus glauca (o).
Rhus mucronata (o).
Rhus tomentosa (o).
Euclea racemosa (o).
Royena glabra (o).
 † *Olea verrucosa* (o).
Hermannia cuneifolia (o).
 † *Salvia africana* (o).
Polygonum atraphaxoides (o)
 † *Athanasia trifurcata* (o).
Leucadendron adscendens (o)
 † *Cliffortia polygonifolia* (o).
 † *Anthospermum ciliare* (o).
Leonotis Leonurus (o).
Rhus rosmarinifolia (r).
Euclea tomentosa (r).
 † *Aster fruticosa* (r).
 † *Peucedanum galbanum* (r).
Cluytia pulchella (r).

(† Common to both lists.)

It will be noted that only seven plants are common to both lists, and, with the exception of a few specimens of *Athanasia trifurcata*, the two families so conspicuous in the seedling list are absent. On the other hand, two families which did not appear in the seedling list are an outstanding feature of this list, viz., Anacardiaceae and Ebenaceae.

The distribution of the seedlings is of interest. Certain of the Leguminosae, viz. *Borbonia cordata*, *Psoralea hirta*, and *Psoralea uncinata*, were

very local in their distribution and formed more or less isolated patches all over the area. It was obvious that these seedlings were all growing close to the spot that had borne the parent plant (or plants), (fig. 5). Another example of this localised distribution of seedlings was found in *Hakea suavolens*. In this case a single, large shrub near the top of the area had been burnt, but owing to its very woody nature it could be recognised. All round the burnt plant was a host of seedlings, and it called to mind a note made by Dr. Harvey in Australia (2) that certain of the Proteaceae native to that country only shed their seeds after prolonged basking in the sun, or after bush fires. *Hakea* is one of the genera mentioned in this connection. The seeds of members of the Compositae on the area (with the exception of *Osteospermum moniliferum*) are all wind scattered, and consequently their distribution was much more general. In point of numbers the plants of *Elytropappus Rhinocerotis* were far in advance of any others, and, with the exception of the northern slopes of the valleys, they were evenly distributed all over the area. This suggests that, as in the case of the Leguminosae, the seeds had withstood the fire and had not been introduced from plants growing in the adjoining unburnt part. Had this been the case, one would have expected to find the numbers of plants at the margin in excess of those near the centre.

The northern and southern slopes of the valleys showed a somewhat striking difference in the bushes which grew on them. The southern slopes were the more sparsely populated, and the chief bushes were *Rhus lucida*, *Elytropappus Rhinocerotis*, *Athanasia trifurcata*, and *Borbonia cordata*. The northern slopes differed from the southern in the diminution in numbers of *Elytropappus Rhinocerotis* and *Athanasia trifurcata*, and the presence of *Myrsine africana*, *Anthospermum ciliare*, *Rhus angustifolia*, *Stoebe alopecuroides*, and *Royena glabra*.

Asparagus capensis, the young shoots of which in the previous year had been such a feature of the landscape, was most inconspicuous. After a careful survey of the area it was clear that the number of plants was about the same as in 1919, but this year no young shoots had appeared before the winter rains, and the old dull-green shoots were easily overlooked. Another noteworthy feature was the absence of flowers in *Haemanthus coccineus*. On the other hand, *Andropogon hirtus* and *Hibiscus aethiopicus* were in full flower, as in the previous year. A plant that had either been absent or overlooked in 1919 was *Linum thesioides*, which was rather sparsely distributed on the southern slopes of valley A.

The area was visited once more in June, but there was little to record. The early months of 1920 were remarkably dry, and the whole vegetative period was somewhat later than usual over the whole Peninsula. The same plants were found as in 1919 (with the exception of the

seedlings already mentioned), and the only additions to the previous lists were :—

- Eriospermum lanceifolium* (o).
- Lobostemon fruticosus* (o).
- * *Eragrostis brizoides* (r).
- * *Disa tenuis* (r).
- * *Chenopodium ambrosioides* (r).
- Watsonia rosea* (r).
- Cotyledon grandiflora* (r).

The winter rains this year were exceptionally heavy, and at one point on the southern slope of valley A there was a small landslide (fig. 6) which caused a large amount of debris to be washed down the water-course, altering this considerably (fig. 7). In several places a deep channel was cut by the rush of mud and stones.

The spring flora, though in composition the same, was by no means as rich as in the previous year, and as elsewhere on the Peninsula the season was considered a good one, one is forced to conclude that the previous year's display was an effect of the fire.

In October records were made of a few plants that had not been noted the previous year, viz. :—

- Indigofera incana* (f).
- Gnaphalium parvulum* (f).
- Lessertia pulchella* (o).
- Silene anglica* (o).
- Lessertia excisa* (o).
- Hypochoeris glabra* (o).
- Carduus pycnocephalus* (o).
- Avenastrum* sp. (o).
- Aizoon sarmentosum* (o).
- Hermannia prismatocarpus* (o).
- Polygala bracteolata* (r).
- Urospermum picroides* (r).
- Pelargonium hirsutum* (r).

During the winter months several water-holes for cattle were dug on the ridge between valleys A and B. In October these holes were nearly dry, and the plants growing in them were interesting in that they were totally distinct from any growing elsewhere on the area. The following were seen :—

- Cyperus tenellus*.
- Crassula brevifolia*.

Juncus bufonius.

Small grass. Not in flower; possibly

Agrostis lachnantha.

This year a visit was paid in November. The only record of note was the abundance of *Ornithogalum pilosum*, a plant which until recently had been considered rare on the Peninsula.

In March 1921, a little over two years after the fire, a few plants of *Antholyza lucidor* were in flower at the top of the patch, but as the particular region in which the plants were found had not been visited in any previous March, there were no records of the behaviour of this species. *Senecio pubigerus*, which in 1920 had been confined to the shelter of the bushes, had spread widely over the slope of valley A and elsewhere was quite a common plant apart from the larger bushes. One young silver tree (*Leucadendron argenteum*) was seen near the top of the patch.

During the late winter and spring months rapid growth took place over the whole area, and on the northern slopes of the valleys a number of seedlings of *Erica viridi-purpurea* were noted coming into flower for the first time. On the slopes between valleys B and C a single plant of *Protea grandiflora* was noted. The shoots of this had obviously come up from the underground stock. On the ridge between valleys A and B a group of young plants of *Relbunium ericoides* and several young plants of *Selago ramosissima* were seen.

The spring flowers of this year showed a still further reduction in number and quality, with the exception of *Babiana stricta*. This species was exceptional in that no obvious effects of the fire manifested themselves in this or in previous years. This may be due to the fact that the corms are unusually deeply seated.

GENERAL CONCLUSIONS.

It is clear that in certain plants rapid growth was induced after the fire, while in others the vegetative parts were wholly killed and the plants had to rely upon their seeds for the continuance of life.

The exact way in which fire influences the plant is not clear. Several factors may be at work. Possibly the heat during the fire acts directly on the underground organs, mobilising all the forces of the plant. It is a well-known fact that by employing high temperatures the normal time of flowering in certain plants may be anticipated (4). In the case of those plants, notably *Asparagus capensis*, in which the flowering period was obviously induced at a somewhat earlier time than usual, it is probable that the heat acted directly on the underground organs. It is also likely that the direct action of heat was responsible for the production of the large number of

flowers of *Haemanthus coccineus*, though in this case the actual time of flowering was the normal one.

In those cases, however, in which the time of flowering was normal, but the number and size of the flowering shoots were greater than usual, it is probable that additional factors were involved. As an example of this type of behaviour we may take the spring Monocotyledons, which have underground storage organs, and whose leaves appear soon after the early winter rains. Owing to the removal of all the bushes their leaves were well supplied with light, and hence we may suppose that their photosynthetic activity was greater than would have been the case had they been overshadowed by bushes. Another factor which may have operated to some extent was the increased warmth of the soil, due to the exposure of the ground to the direct rays of the sun. The winter, however, in the Cape Peninsula is very mild, and it seems likely that light rather than heat is the predominating factor.

The following suggestions are put forward as to the ways in which fire may influence the soil and thus benefit the plants :—

1. The physical effects of fire on the upper layers of soil may be such that increased aeration is brought about.
2. Soil protozoa, which are known to have a retarding influence on the growth of plants, are very sensitive to high temperatures (1), and the number of these organisms may be considerably reduced.
3. The ash from the burnt plants may have a certain manurial value, thus enriching the soil chemically.

No definite example was met with of a species which had been eradicated by burning, though there is no direct evidence to show that such a species did not exist, since the area had not been surveyed before the fire. The evidence that one relies upon in drawing the conclusion is the composition of the unburnt surroundings. This, however, is far from satisfactory, owing to various factors such as cultivation, etc.

One fact is clear, and that is that burning favours the spread of the "Rhenoster Bush" (*Elytropappus Rhinocerotis*). The type of vegetation now established on the site of the fire is similar to that termed by Marloth "Rhenosterveld" (fig. 6), and the foregoing lends support to his view that this formation is an artificial one (3).

Another result of a bush fire on a slope such as this is obvious. The soil is laid bare, and cases of erosion—some slight, some marked—were common all over the area.

While making the observations just recorded, several interesting facts were noted, which, though they have no direct relation to the subject under discussion, are nevertheless striking and may be mentioned here.

The Peninsula flora is characterised by the presence of certain families which are typical of the south-western districts, but are either lacking or scarce in South Africa beyond these limits. The area under discussion is singularly deficient in a number of these families. Bruniaceae and Penaceae are entirely absent, the family Restiaceae is represented by a single specimen, and members of Proteaceae, Rutaceae, and Ericaceae are only occasionally seen.

It has been suggested, especially in the case of the Proteaceae, that bush fires have been largely instrumental in eradicating large numbers of species from these slopes. This suggestion, however, does not explain why it is that most of the families mentioned above are well represented on the slopes below Lion's Head, which slopes in their vegetation incline to the true "Macchia" type. It is significant that the soil here is derived from granite (fig. 1), and as bush fires have occurred in plenty, it seems reasonable to conclude that the soil may be the determining factor in the case.

The problem needs further investigation, but certain facts such as the dominance of *Blaeria ericoides* at certain spots on the granite soil, and the scarcity of the family Ericaceae on similar positions on the slate, lead one to the conclusion that the soil in this particular instance has a profound influence on the vegetation.

My thanks are due to Professor Thoday for his kindness in taking the photographs which illustrate this paper, and for the many helpful criticisms which he has offered from time to time during the progress of the work.

SUMMARY.

1. The bush fire, the effects of which are recorded, broke out on the 5th February 1919 and burned for two days, killing all the aerial parts of plants on the slope.

2. About three weeks later considerable growth had taken place in *Asparagus capensis* and *Andropogon hirtus*. Shortly afterwards *Haemanthus coccineus* and a few other less notable plants were in flower. Various species of *Rhus* were putting up shoots.

3. The early winter and spring flowering periods were characterised by an abundance of vigorous flowering shoots. These appeared at the usual time. In the majority of cases these plants possess underground storage organs. Progressive decrease in numbers and vigour of plants flowering during these periods was noted in 1920 and 1921. Suggestions are made to account for the phenomenon.

4. Numerous seedlings came up during the winter of 1919, but in general these were not identified till the next year.

5. The northern, shaded slopes of the valleys showed a conspicuously different plant population from the southern exposed slopes during the winter months. In the summer months the contrast was not as sharply marked. This is attributed largely to the fact that in winter the sun shines on the northern slopes for a short period only of the day, while the southern slopes get most of the available sunlight.

6. During 1920 the shrubs were divided into two classes: (a) those where the underground parts had survived the fire and from which new shoots arose, and (b) those which were killed by the fire and which reproduced themselves by seed. The *Rhenoster* bush falls in class (b), and is clearly favoured by burning.

7. The removal of the vegetation by the fire helped the process of soil erosion. This process was also aided by man and cattle. Several small washaways occurred on the area subsequent to the fire.

8. The area is shown to be deficient in several typical south-western families, but to what extent this may be attributed to the influence of repeated fires is not clear, and the view is brought forward that soil may be the determining factor in this case.

LITERATURE CITED.

- (1) HALL, Sir A. D.—*The Soil*, third edition, 1920.
- (2) HARVEY, W. H.—*Memoirs of Dr. Harvey*, 1869.
- (3) MARLOTH, R.—*Das Kapland*, Jena, 1908.
- (4) PALLADIN, W.—*Plant Physiology*, edited by B. E. Livingston, 1918.
- (5) PHILLIPS, E. P.—“A Preliminary Report on the Veld-burning Experiments at Groenkloof, Pretoria,” *South African Journal of Science*, xvi, 1920.
- (6) PHILLIPS, E. P.—“Veld-burning Experiments at Groenkloof,” *Union of South Africa, Department of Agriculture, Science Bulletin*, No. 17.

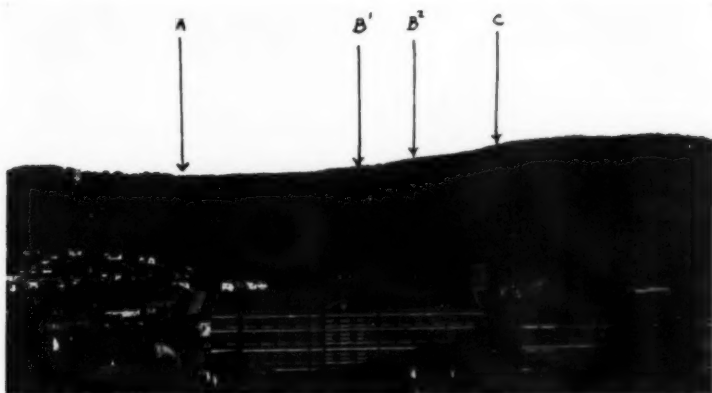


FIG. 2.—Photograph of burnt area on Signal Hill, taken from the roof of the Natural Science Building, University of Cape Town, two and a half years after the fire.



FIG. 3.—Southern part of the burnt area, looking up the hill. The foreground is covered with bushes of *Acacia horrida*, and was not touched by the fire. The fenced-in region may be distinguished from the open hillside by the presence of numerous old inflorescences of *Andropogon hirtus*.



FIG. 4.—Detailed view of some of the seedlings which have grown since the fire. In the foreground is a patch of *Borbonia cordata* and a few plants of *Cliffortia ruscifolia*. The plants in the background are mainly *Elytropappus Rhinocerotis*, the two larger shrubs being *Rhus lucida*.



FIG. 5.—A "school" of young plants of *Psoralea hirta*. The darker bushes are *Rhus lucida*.

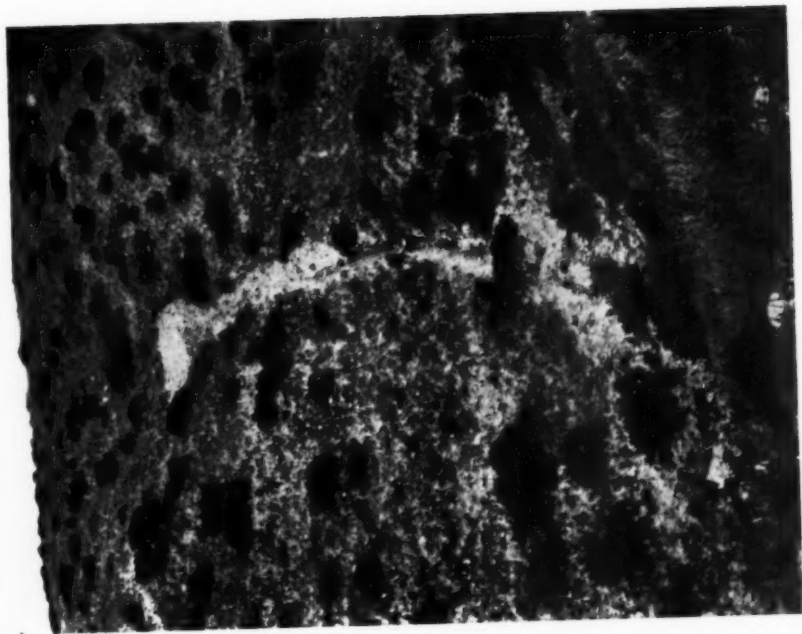


FIG. 6.—Small landslide on the southern slope of valley A. Photograph taken from the northern slope of the same valley.

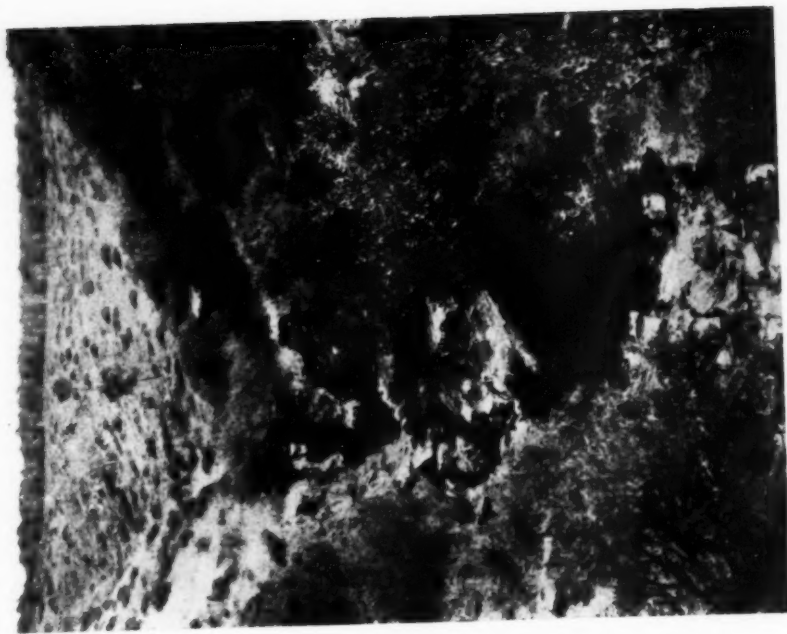


FIG. 7.—Looking up valley A. The water-course has been much cut up by the rush of mud and stones from the landslide depicted in fig. 6.

Seidl & Co., Ltd.

COLOUR AND CHEMICAL CONSTITUTION.

PART XVI.—FURTHER MISCELLANEOUS OBSERVATIONS.

By JAMES MOIR.

The main lines of the theory of the colour of "cyclic" coloured substances having been established in Parts X, XIII, and XIV, it only remains to put on record observations of the absorption wave-length of all the "monocyclic" and "dicyclic" colours which I have used in making the discovery, but have not published for fear of overloading these theoretical papers with unnecessary detail.

A. DERIVATIVES OF THE PROTOTYPE COLOURS.

1. *Orthopara-* or (2-4')-dioxybenzhydrol, from salicylaldehyd (see Beilstein, ii, 1114). This has λ 543 (broad) in alkali, λ 486 in HCl, and λ about 495 when in suspension in neutral water. The isomeric *p-p*-compound has λ 539 in dilute alkali, but in HCl has the same λ as the *o-p*-compound.

2. 2-oxy-4'-dimethylaminobenzhydrol, from salicylaldehyd and dimethylaniline, has λ 561 (broad) in alkali, with λ 500 in HCl. The isomeric 4-4'-compound has λ 572 in alkali and λ 504 in acid. This was predicted (as λ 571) in Part XII, top of p. 211.

3. 2-4-4'-trioxybenzhydrol, from *p*-oxybenzaldehyd and resorcin, appears to have λ 494, whereas λ 550 was expected: possibly the reaction is abnormal.

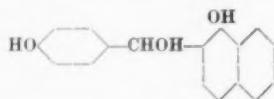
4. 2-4-dioxy-4'-methoxybenzhydrol, from anisaldehyd and resorcin, has λ about 380 in alkali. This substance appears to be monocyclic, since 2-4-dioxybenzhydrol has a similar λ .

5. 2-4-dioxy-3'-4'-dimethoxybenzhydrol-2'-carboxylic acid, from opianic acid and resorcin, has λ 390 in alkali. This is also monocyclic, being a derivative of monophenolphthalein (Part XIII, p. 38).

6. Mono- α -naphtholphthalein, from phthalaldehydic acid and α -naphthol, has λ 370, and is also monocyclic.

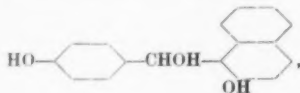
7. C-phenyl-derivative of foregoing, from benzoylbenzoic acid and α -naphthol, has λ 401 in alkali. In strong sulphuric acid, however, it has the much higher colour λ 543.

8. 1-4'-dioxybenznaphthdrol, from *p*-oxybenzaldehyd and α -naphthol, is violet with λ 590 in alkali. I have assumed the constitution to be



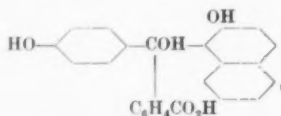
on the analogy of naphtholphthalein (Berichte, 1920, 1445).

9. The corresponding substance from β -naphthol,



or 2-4'-dioxybenznaphthdrol, has λ 556, with a pink colour.

10. Phenol- β -naphtholphthalein, the benzoic acid-derivative of the foregoing,



is now found to have λ 570 (broad). My statement in Part II (1918, p. 113), that it has λ 637, is erroneous.

The naphthol/phenol colour-factor from these two substances is quite different from that obtained when the C_6H_4 group of the naphthalene-ring is joined *metapara* to the benzhydrol linkage, viz. 1.026 for *orthometa*- as against 1.082 for *metapara*-attachment.

From these data I can roughly predict the wave-length of the still unknown *p-p-a*-naphtholphthalein to be about λ 628, that of the commercial *o-o-a*-naphtholphthalein being λ 662.*

B. FURTHER DERIVATIVES OF PHENOLPHTHALEIN (Part IV—continued).

(a) 3- (or 6)-oxyphenolphthalein, from 3-oxyphthalic acid, has λ 556 in NaOH and is higher in bicarbonate (λ 562).

* When, however, the hydroxyl is *para* to the benzhydrol linkage, a third naphthol/phenol factor comes into play. Its value is 1.042 (see Part XV, Naphthofluorescein). The true calculated λ of *p-p-a*-naphtholphthalein is 602. This is also the factor for safranines like Magdala-red.

(b) 3-6-dioxyphenolphthalein, from Thiele's dioxy-acid, gives a large difference between caustic and bicarbonate colour, viz. λ 549 and λ 563 respectively.

(c) 4-5-dioxyphenolphthalein, from normetahemipinic acid, gives a similar difference, viz. λ 558 in NaOH, and λ 568 in NaHCO_3 .

(d) 5-methoxyphenolphthalein, from 4-methoxyphthalic acid, has λ 565.

(e) 3-6-dimethoxyphenolphthalein has λ 568.

(f) 4-5-dimethoxyphenolphthalein ("phenolmetahemipineine") has λ 556.

(g) 5-6-dimethoxyphenolphthalein ("phenolhemipineine") has λ 571.

I have to thank the Institute of Chemistry for obtaining for me small quantities of the necessary acids from unknown donors in the English universities.

(h) 3-nitrophenolphthalein, from 3-nitrophthalic acid, has λ 570. The value λ 559 was given in 1918, and is erroneous.

(i) a-nitro-fgjk-tetrabromophenolphthalein has λ 597 (blue-violet). (See Part XI, p. 130, for the nomenclature.)

(j) 5-nitrophenolphthalein, from 4-nitrophthalic acid, has λ 572. Its tetrabromo-compound has λ 599.

(k) 3-4-5-6- (or abcd)-tetrachlorophenolphthalein ("phenoltetrachlorophthalein") has λ 581, scarcely different from that of the common (fgjk) isomer, viz. λ 583.

(l) Phenoldimethylalphanaphthylaminephthalein is green, λ 625.

C. DERIVATIVES OF GHOSH'S QUINOLINIC ACID.

These are phthaleins with N for CH in the phthalic ring.

I. Phenolquinolineine has λ 533.

II. Orthocresolquinolineine has λ 544.

III. Thymolquinolineine has λ 593.

IV. Resorcinquinolineine has λ 490.

V. Orcinquinolineine has λ 496.

D. DERIVATIVES OF TRIPHENYLCARBINOL.

1. Ortho-oxy-malachite green (salicyl-green) has λ 627 in neutral solution, λ 572 in alkali, and λ 505 in acid.

2. 2'-oxy-4-dimethylaminofuchson (foregoing with OH for NMe_2) has λ 490 neutral, λ 533 in alkali, and λ 479 in acid.

3. *p*-methoxy-malachite green, from anisaldehyd, has only one colour, viz. λ 605.

4. *p*-Methoxybenzaurine (=aurine methyl ether) has λ 551.
5. Dimethylaminodioxypheylidinaphthylcarbinol, from dimethylaminobenzaldehyd and α -naphthol, has λ 730 when neutral and λ 492 when acid.
6. 2-2'-4-4'-tetraoxytriphenylcarbinol has λ 516 (non-fluorescent). On heating with zinc chloride this gives resorcin-benzein, λ 492 (very fluorescent).
7. Paranitro-malachite green has λ 642 in water. Formánek gives λ 637 in alcohol. The band is vague and not easily measured.
8. Nitro-oxy-dimethylaminotriphenylcarbinol, from 4-nitro-4'-oxybenzophenone, has apparently λ 610, whereas calculation gives λ 575. This requires reinvestigation.
9. Para-amino-malachite green (unsymm. tetramethylfuchsine), from reduction of No. 7, has λ 581 in acetic acid, λ 610 vague in stronger acid, and is yellow in HCl (λ about 420).
10. 2-2'-4-4'-4"-pentaoxytriphenylcarbinol (dioxaurine) has λ 545.
11. Unsymm. dimethylparafuchsine, from dimethylaminobenzaldehyd and aniline hydrochloride, has $\lambda\lambda$ 547 and 493 when neutral, but when acidic shows vague bands at about λ 575 and near the red end (over λ 700), which is surprising.

E. VARIOUS SIMPLE COLOURED SUBSTANCES.

- (a) Quinonoxime. This has two vague bands at both ends of the spectrum, viz. about $\lambda\lambda$ 680 and 350.
- (b) Sodium salt of foregoing (Na-*p*-nitrosophenol). In water λ 398. Baly gives λ 415 in alcohol.
- (c) Nitrosodimethylaniline. The green base has λ 415 + λ 725. The acetate has λ 457 alone: the chloride in HCl λ 390.
- (d) 2-3-dicyano-quinol. This is colourless, but with a very strong fluorescence: λ about 330 neutral, λ 410 alkaline. The fluorescence of the salts of this substance is extraordinary, so that this is probably the simplest highly fluorescent substance.
- (e) 3-6-dioxyphthalimide (from hydrolysis of above). This is yellow with λ 405 when neutral, but λ 480 in NaOH: highly fluorescent.
- (f) 3-6-dioxyphthalic acid. When neutral this is nearly colourless with λ 370. Alkali turns it yellow (λ 437) with a marvellous fluorescence. The fluorescence must depend on the juxtaposition of ONa and COONa, since I find that sodium salicylate, when examined in presence of NaOH in sunlight, shows a fluorescence (violet).

F. UNCLASSIFIABLE OBSERVATIONS.

- I. Quinizarine: chief band λ 598.
- II. 2-chloroquinizarine: chief band λ 601.

- III. α -Naphthofluorane in conc. H_2SO_4 has $\lambda\lambda$ 500 and 475.
IV. Phenosafranine ("desensitol") has $\lambda\lambda$ 525+505 in water, and $\lambda\lambda$ 532+497 in alkali.
V. Quinhydrone in $AmHCO_3$: λ 480 broad.
VI. Tetrabromo-quinhydrone in $NaOH$: λ 510. (2 2'-6-6' variety.)
VII. Quinhydrone of dimethylphenylenediamine: $\lambda\lambda$ 558+513.
VIII. " " tetramethylphenylenediamine: $\lambda\lambda$ 614+568.
IX. " " dihydrophenazine: $\lambda\lambda$ 701+640.

Note.—The quinhydrones obey the dicyclic colour laws, but the oxidation-factor is $\frac{2}{3}$, not $\frac{3}{2}$.

ON HYALITE.

By J. S. V. D. LINGEN and A. R. E. WALKER.

The investigation of hyalite, some of the results of which are recorded in the following note, first suggested itself to the authors whilst they were engaged in studying the optical behaviour of liquid spherulites.

An attempt was being made to find a solid spherulitic body analogous—both as regards internal structure and optical behaviour—with the type of liquid spherulite described by Lehmann, in which the molecules of the substance are regarded by him as being arranged either along lines radiating outwards from the centre of the spherulite, or on the surfaces of spheres possessing a common centre—the centre of the spherulite.

As a result of a preliminary examination of a number of substances selected for this purpose, hyalite was chosen as being the most promising.

In this way one was led to consider the nature of what is commonly termed the “anomalous double refraction” of hyalite. In this connection Dana * writes as follows :

“ (Opal) often shows double refraction similar to that observed in colloidal substances due to tension. The mammillary form *Hyalite* often yields the uniaxial interference cross of a negative substance in parallel polarised light; † this is referred to tension by Schultze, Ber. nied. Ges., 69, 1861.”

Similarly Rosenbusch ‡ :

“Hyalite is doubly refracting, and, under certain conditions, exhibits the interference cross of a uniaxial substance with isochromatic curves. This appearance is referred to conditions of strain occasioned by the concentric shell-like structure of the mineral. The character of the double refraction is negative. The hyalite cross often separates into hyperbolas during a rotation of the section between crossed nicols, which would necessarily be the case if the layers were not regular spherical shells.”

* Dana, A System of Mineralogy, 6th ed., p. 194.

† The italics are ours.

‡ Rosenbusch (Iddings), Microscopical Physiography of Rock-making Minerals, 4th ed., p. 194.

The material investigated was supplied to the Geological Department of the University of Cape Town by Foote of Philadelphia, and is labelled as having been obtained from Guanajuato, Mexico.

The specimen represents a portion of a succession of deposits which presumably originally lined a rock cavity. Several "forms" of silica—some chalcedonic, others opaline—are represented, and, in our opinion, judging from this single specimen, a definite order of deposition is observable.

We infer that, throughout a period of continuous deposition, the chalcedonic varieties were deposited at the commencement, and the opaline varieties towards the close, of such a period.

These varieties, enumerated in the order in which we consider them to have been deposited, are as follows:—

Chalcedonic Silica.

1. Dark chocolate-brown variety resembling jasper.
2. Opaque, white; in parts bluish-white.
3. Pale blue or bluish-white, semi-translucent; botryoidal (pale brown by transmitted light).

Opaline Silica.

4. Clear, colourless, botryoidal hyalite.
5. Extremely pale bluish-white, opalescent or slightly clouded hyalite; spheroidal in form, and much less common than the colourless and water-clear hyalite. (Since this variety generally occurs forming semi-spheroid masses on the surface of the clear hyalite, no difficulty is experienced in distinguishing between the two—particularly when both are immersed in water,—but, when the slightly clouded variety is detached from the clear, optical examination proves the surest method for its identification. It is important to note also that, in certain parts of the specimen, the small semi-spheroids of this variety are coated with a thin layer of clear hyalite.)

Apparently the forms of silica enumerated above were not the result of one continuous period of deposition, but of several such periods; nor was deposition uniform over the whole surface of the cavity throughout each period. Several repetitions of the sequence 2, 3, 4, 5 are observable.

In the following we refer principally to two kinds of thin sections, which, for convenience, we propose to name "diametral" and "tangential" respectively. By "diametral section" we mean one cut approximately through the centre of a spherulite; by "tangential section" one prepared from the surface layer of such a body.

Throughout the preparation of any one section the material was closely observed in order to see whether the grinding—the process by which all

the sections were made—had caused to appear within the material any structures which might be attributable to a release from internal strains consequent on the destruction of the spheroid. Nothing of this nature was observed. Occasionally a section would break along irregular cracks, but, generally speaking, they retained their circular outline unbroken and did not show, when examined under the microscope in ordinary transmitted light, any signs of a strained internal concentric structure.

THE COLOURLESS AND WATER-CLEAR HYALITE.

Diametral Sections.

(a) *Examination in plane polarised light.*

A diametral section of this variety, when placed on the stage of the microscope so that the axis of the microscope passes through the centre of the spheroid, exhibits, when examined in plane polarised light between crossed nicols, a figure consisting of a black cross with isochromatic rings resembling that given by a uniaxial mineral in convergent polarised light. On the insertion of a quarter undulation mica plate the figure behaves in a similar manner to that of a negative uniaxial substance; many sections were tested in this way, and in all cases the sign was negative. A movement of the section, however, causes a movement of the figure, so that whenever the section is excentrically placed the figure resembles and behaves like a partial uniaxial figure. On this account we do not regard this figure given by hyalite as being analogous with that of a uniaxial mineral in convergent polarised light; sections of radiating chalcedony (described by Miers as a biaxial mineral) and diametral sections of oolitic grains have been observed to give, under similar conditions, figures resembling, both in general appearance and optical behaviour, those given by hyalite.

(b) *Examination in convergent polarised light.*

The behaviour of diametral sections in convergent polarised light is essentially similar to their behaviour in plane polarised light.

Tangential Sections.

(a) *Examination in plane polarised light.*

Tangential sections, between crossed nicols, are either quite isotropic or show very slight graying marginally.

(b) *Examination in convergent polarised light.*

In convergent light a tangential section yields a figure composed solely of a black cross; owing to the thinness of the section and the weak strength

of birefringence of the mineral, no colours are produced. The cross remains stationary within a comparatively wide range of motion of the section ; on the rotation of the latter it breaks up into two hyperbolæ—but this separation, although apparent, is so slight that we hesitate to proclaim the biaxial nature of the figure. We do, however, regard it as being a true axial figure.

The sign of the mineral, determined from these figures by means of a quarter undulation mica plate, is negative.

THE OPALESCENT OR SLIGHTLY CLOUDED HYALITE.

Thin sections of this variety have a very faint brownish tint when viewed by transmitted light. The important difference between this and the clear hyalite, so far as optical behaviour is concerned, is in the sign of the double refraction ; whereas the nature of the double refraction of the clear is negative, that of the slightly clouded is positive. In other respects, what has been written concerning the clear applies also to this variety.

COMPOUND SPHEROIDS.

Mention has been made of the occurrence of spheroids of the slightly clouded hyalite having an external layer of colourless hyalite. A section intermediate between a tangential and a diametral section was prepared from one of these. When this section was examined in plane polarised light it exhibited an extinction figure composed of a black cross and a black ring—the latter being comparatively close to the margin of the section. On testing this figure with a quarter undulation mica plate it became apparent that the black ring was of the nature of a compensation band resulting from the overlapping of the two varieties—positive and negative—consequent on the curvature of the spheroid.

Subsequently a section was made through a cluster of such spheroids, which, on examination, revealed the fact that in some spheroids there is a repetition of concentric layers of positive and negative material.

FURTHER EXPERIMENTS AND OBSERVATIONS.

(a) *Examination by means of X-rays.*

X-rays were passed through a thick diametral section of the clear hyalite, and the effect of the mineral on the rays was ascertained by means of a photographic plate—after the method of von Laue. The "pattern" showed that, for a given radius, the dispersion had been uniform around the central spot.

(b) *The effects of heat.*

It was observed that, when a fragment of clear hyalite was heated on platinum foil in a bunsen flame, thin flakes split off from its surface, and that these flakes eventually curled and became portions of spherical surfaces; in addition they lost their glassy appearance and turned opalescent.

A somewhat thick diametral section, placed on a glass slip and heated as above, became opalescent and curled into a concavo-convex shape, whilst at the same time a small spherical kernel split out from its centre. When the concavo-convex portion was examined under the microscope, it was found to have a pale-brown colour by transmitted light; further, between crossed nicols in plane polarised light it yielded an extinction figure having a positive sign—that is, having the same sign as the naturally occurring opalescent hyalite previously described.

Portions of some of the flatter opalescent shells obtained by heating behaved in a very similar manner to tangential sections of the naturally occurring form.

(c) *Chemical examination.*

Material was submitted to Mr P. R. v. d. Riet Copeman for analysis, with a view to finding out what chemical change had accompanied the change in sign produced by heating. From a series of silica determinations, and assuming the general formula of hyalite to be $\text{SiO}_2 \cdot n\text{H}_2\text{O}$, he arrived at the following conclusions:—

1. The loss—presumably water—on heating the clear hyalite at bunsen heat was 2.98 per cent.
2. The clear contains 10.28 per cent. water.
3. The naturally occurring opalescent hyalite contains 7.55 per cent. water.

From the above it appears that the artificially produced opalescent hyalite has almost the same water content as the naturally occurring opalescent form.

REMARKS IN CONCLUSION.

Our chief object in writing this note has been to record observations pending the arrival of more material for further investigation. At present we feel we can only write tentatively regarding the reasons why hyalite is doubly refracting. We consider that the explanation that it is due to tension is, at the best, an insufficient one; we are inclined to regard the occurrence of spheroids composed of concentric layers of positive and negative material as making this view—considering it as being the sole explanation—untenable.

We would suggest that hyalite is a substance of which the component

molecules are anisotropic unities ; that their arrangement in the naturally occurring forms may be due to strains, but that their crystallographic orientation, on which the sign of the double refraction depends, is due to their water content.

One of us * has shown in a previous paper how, by gradually driving off the water which it contains, the internal molecular structure of brucite is changed ; this change is tantamount to an alteration of the axial ratio of the mineral. Keeping this in mind, and taking into consideration also the fact that whenever the clear negative hyalite is heated to redness it becomes converted into an opalescent positive material resembling the naturally occurring opalescent hyalite, we cannot help but feel that the water content is the most important factor in deciding the nature of the double refraction of hyalite.

That tangential sections of hyalite behave as uniaxial—or biaxial ?—mineral substances we regard as evidence in support of our contention that the molecules are in themselves anisotropic.

In conclusion, we wish to thank the Royal Society of South Africa for the grant in aid of research.

* J. S. v. d. Lingen, *Trans. R. Soc. S. Afric.*, Vol. VII, Pt. 1, 1918, p. 59.

CIRCUMCISION REGIMENTS AS A NATIVE CHRONOLOGY.

By the Rev. Professor W. A. NORTON, M.A., B.Litt.

The regiments of the successive circumcision lodges, holden about every five years in most tribes, form a rough method of fixing the chronology, by comparing the *mephato* or regiments circumcised in different tribes at the time of the same event or reign. For example, the well-known chief Sechele, Livingstone's friend, was remembered in the neighbouring tribes as having been contemporary with such-and-such a chief, by circumcision, as a youth. Having fixed the date in last century, therefore, of his circumcision, one can deduce the dates of *mephato* in the other tribes. At the beginning of my work as a Government research grantee I cast about for some subject which would be virgin ground, and at the same time have a wide general bearing on the comparative history and folklore of the tribes. I lit upon this interesting subject, and found my researches well rewarded; seeing that I was able to collect regiment lists in some thirty of the central South African tribes, some of these lists running well back into the eighteenth century. That veteran scholar, Fr. Bryant of Natal, has worked out a valuable list of Zulu regiments: but practically nothing seems to have been done in the case of the more Western tribes.

The interest of these regiment lists is manifold. They are the natural scaffolding of native history. For years, as a missionary, I wasted hours, as had my predecessors, in dating the births of baptismal candidates by wars or comets, before discovering that the terse query "O leng?" brought the terse answer "Ke le-tlhaselwa" or "Ke le-fitlha-Kgosi," at once approximately dated the person's circumcision (usually about the age of eighteen). However adequate dating by wars may be in the war-worn South-East Africa, the wars of the Bechwana or Basuto were mostly short raids, and infinitely more cumbersome and uncertain for dating purposes than the regiments. Of course the regiments must first themselves be dated *once for all*, to which necessary work this paper is contributory.

I withhold further remarks on the lists in detail till readers, who are working with the individual tribes, have had the opportunity and goodness to check them, as I hope they will, by researching into tribal history with their help. I shall be deeply grateful if those who are not arranging to publish such research themselves will kindly put it at our disposal, to be

correlated and, if possible, published at an early date, with due acknowledgments.

I am convinced that what native history is still to be gathered must be gathered at once, from the old men with memory of it. Time and again have I been told, during the last few months, that old people have just died who could have answered my question (the younger generation are woefully uninterested). Could not those in touch with such make the future their debtor by an effort to record their recollections within the next few months? Even where such record were not available for co-operative history, as I suggest, I should be grateful to have the names and whereabouts of such sources of information, in case some doubtful point within their memory needed to be cleared up. Suggested names of officials, missionaries, or settlers who have studied the tribes, or have long experience of them, would also be gratefully received.

One thing I especially ask: that those who co-operate in this urgent work of salvaging the last remnants of these recollections would take care to give the regiment (*mophato*) names contemporary with each incident as well as the date A.D. where that can be fixed.

In conclusion, I might mention that the significance of the regiment name itself often throws light on the history, as will be seen in two examples given above (*v. index* under *-tlhaselwa* and *-fitha-Kgosi*), and also on the feeling of the tribe at the time. The spelling even reflects the variant pronunciation, as (*seTlhaping*) *hachane* for *fatshwane* and (*seTlokwa*) *hiri* for *firi*.

N.B.—The following meteorological dates have been kindly checked by H.M. Astronomer at the Cape, and may be useful in fixing others:—Comets in 1811–2, Nov. '43, '58–9, '82; meteors, Nov. 27, 1885; total solar eclipses, Nov. 19, 1835, and April 16, 1874.

I regret that data I have been looking for concerning the ancient tribe of the ba-Hurutse have not yet arrived: I trust workers in that and other spheres will kindly help me with information and correction. I beg to thank the reigning chiefs Kgama, Lenewe, Sebele, Lotlamoreng, Seboko, Gaborone, and their counsellors, the chieftainess Moletshi, the chief Segale and others of his family, especially the teachers Amos and Seth Pilane, and masters and scholars at Pietersburg Training College, Tyger Kloof, etc., for valuable help in preparing this paper: also the Government officials of the Native Affairs Department and of Bechuanaland, Basutoland, and the Transvaal, for constant kindness and help in every way.

NOTE TO INDEX OF REGIMENT NAMES.

N.B.—In all but the two or three cases where I have given the special prefix, the prefix *ma* is to be understood before the form given in the index as collective name of the regiment: the individual member of it uses the singular prefix *le-*; hence the formula for asking one's regiment, "O le-ng?" i.e. "You are le-what?" To find the *mophato* preceding or following,

one asks: "A rupisitswe ke mang?" or "A rupisitse mang?" (i.e. they were circumcised by, or circumcised, whom?), and so builds up or checks the list of successive *mephato*.

Lists 1-14 of the Transvaal tribes very rarely have the composite names which are characteristic of 15-25, those of Bechuanaland, showing a different strain of cultural borrowing where not of original descent.

INDEX TO REGIMENT NAMES OF TRIBES OF TRANSVAAL AND
BECHWANALAND.

- ma-abaNKwe, dividing the sheep, 22.
- abaNtwa, ordering the host, 20.
- alola, removers (intrans.), 15; alosa, do. (trans.), 25.
- abaKgomo, sharing the cattle, 19, 23-25.
- aparaNkwe, wearing leopard (skins), 8, 17.
- apaPula, spreading the rain, 25.
- bapoga, outstretched, erect (? aba Phoha, distributing feathers), 15.
- betlwana, those cut or chipped (i.e. in circumcision), 17.
- bitsi, callers, 1, 4.
- butswane, the ripe ones, 11.
- busa, turning back (the enemy), 24 f.
- betla-Kgang, fashioning strife, 23.
- chologa (for thologa, *q.v.*), 23.
- cecele, clever (for tsele-tsele), 8*, 9*.
- chedi, gushers, 13.
- chama, undaunted, 8, 17.
- ea-ka-Kgang, going with strife, 18, 20.
- ea-ka-Kgosi, going with the chief, 23.
- ea-ka-Thata, going with strength, 17-19, 21.
- ea-ka-Thebe, going with a shield, 19, 24.
- emelwa, championed, 15 (or waited for, because kept long uncircumcised).
- ea-ka-Ntwa, going with a host, 18-21.
- ea-ka Pula, going with rain, 18 f.
- fatlha, defenders, 8, 12.
- fatshwa, dappled cattle, 15 (or phatshwa).
- fatshwana (dim. of above), 8*.
- firi, hyenas, 8, 16, 17 (hiri).
- fitlha-Kgosi, buriers of the chief, dying during rites, 18 (of Chief Ikaneng), 20 (Gopane), 26 (Thapuse).
- folosa, those that bring down, 15.
- fulaca, turners (of the enemy), 1.
- fenya, defenders, 24 ? f.; a Ramphelana (of R.=Bogacwi, chief of regt.), 8.
- fenyaKgosi, chief's bodyguard, 21.
- fikang, making fast, 26.
- ga-e-Kgomo, no cattle, 22 (27); gaenaKgomo, having no strife, 22.
- lo-gaga, the cave (collective name of regiment), 19, 23.
- gata, trappers, 8, 16 f., 24 f.
- gasa, scatterers, 9 f., 13, 24.
- gata-Kgomo, treading on cattle, 19, 22 f.

- gana, refusers, 14; and a ba-Modimosane ba-Matau regiment, 1901.
 ganelwa, those put off, refused, or quarrelled with, 8, 14, 16 f., 20, 22
 (? ganela, refusers), 23, 25 f.
 gana-Kgomo, refusing cattle.
 gana-Mokgwa, refusing the custom (*i.e.* of circumcision), shirking
 circumcision, 16, 20 f.
 gana-Tsatsi, avoiding the daylight (*i.e.* beasts of prey), 16.
 godimo, those above, 16.
 godiri (a plant-name), 16.
 goiwa, those acclaimed, 17.
 gala-tladi, shrieking like the thunderbolt, 23.
 godu, thieves, 23.
 golopo, 9 f., who are asked ?
 gora-Poto, lickers of the pot; a baModimosana ba-Matau regiment,
 1900 ?
 gwasa, roaring like the waters, 17, 19, 23, ? 26.
 mo-golodi, liberators or blue crane (*ac. to tone*), 22.
 "gou-Kom!" ("Come at once!" prob. a tribute to the emphatic ways
 of the Voortrekkers, or the Bastaards before them), 22.
 German, c. 1814, 20.
 gapela, seizing for (the chief ?), 24.
 hiri, *v. firi*, 17.
 hachane, *v. fatshwane*, 22.
 lo-haha, the (ostrich) feather (collective name of regiment wearing it ?), 22.
 henyakgosi = f-Kg, 22*, 27.
 hlaba (*v. tlhaba*), stabbers, 13.
 hl[w]ana (*v. tlhwana*), 1, (6).
 hohu, herd of eland (phofu), 3*, 4-7.
 ilwa, avoided, 25.
 isaKoma, bringing the war-song, 8.
 isaKgosi, bringing the chief, 21.
 isaNkwa, bringing the host, 19, 21.
 ipofhi, binding themselves, 18.
 ilaMotse, avoiding the stad, 17.
 ilaNkwe, avoiding the leopard, 8.
 ilaKgang, avoiding strife, 23.
 jaNko[u], those that eat the nose (sheep), 1, 8.
 jane, little vessels, 14.
 jaKgomo, beef-eaters, 14, 22, 24 f.
 jaPoho, bull-eaters (? sacrificed before circumcision), 18, 24 ?.
 jaTau, lion-eaters, 22.
 jweTshepe ?, stones of iron, 15.
 kaka, thorn trees, or the stout ones, 16.
 keretla, bellows, 1.
 [k]galwa, those (de)cried, 1*, 2, 9 f., 13.
 kgari (? kgare, wreath of grass on head of carriers), 14, 25.
 kgau, corn dried up in sun ?, 2, 6.
 kgOba [Motse], troubling (the stad), (10), 15.
 gomoca, comforters, stilling cries (? ironical), 14.
 kgwadiba, ox-tripes, 9*.

- kgwa, spitters, [10], 16.
koba, driving away in contempt, 2, 7 f., 10 f.
Komponi (modern name "compound" of mine, etc.), 17.
kuka, the lifters, 8.
kwa, discoverers, 10 f.
kete-kete, so-and-so, 8 (-soswe).
lataKgosi, bringing the chief, 19, 23.
letaKgosi, awaiting the chief, 22, 25.
leta-Pene, bringing the vanguard, 22.
llelaKgosi, lamenting the chief, 17.
lat[1]hwa, castaways, (3)*, 6 (lahlwa).
lalaMetlwa, bivouacked among thorns, 8 (also called lallaDira, ambushed for the enemy; and laAibilwe, sleeping in battle-order, in list 16*).
lau (the parts of) the lion (tau), 1, 19, 22 f.
lekana, mates, 4*.
letaNtwa, awaiting war, 16.
lekaNtwa, attempting war, 15, 19.
lobela, ? denying falsely, 11.
lomaKgomo, biting the ox, 15-17.
lwelaKgosi, fighting for the chief, 16, 19.
lwelaNaga, fighting for the land, 19, 23.
lwelaMotse, fighting for the stad, 8, 15, 17 f., 20.
lokwana, bead necklace (perhaps orphans, so decorated; the regiment following Montsiwe's death so called among baRolong), 19, 23, 26.
losaNkwe, leopard-slayers, 19 (l-Tlou, elephant, do.).
loto, warning (or from a plant name), 12.
dila, sour milk, or the smearers, 23.
dima, cattle out at grass, 7, 8*, 9-11, 13.
dingwana, little cannibals, or whirlwind, 3*, 4 f., 7 f., 10, 13.
disa[Kgomo], herding (oxen), [10], 23*, 26.
dupe, fine rain, 15.
dikwa, surrounded (a forlorn hope), [10].
disaKgosi, tending the chief, 21.
dihMotse, letting down the stad, 22.
N.B.—The *D*'s are placed here as the *l* sound in Suto-Chwana is really a cerebral *L*, and connected with that letter etymologically.
metsaPhala, great snakes (lit. rooibok-swallowers), 23.
nala, nail (? naila), [10].
nare, wild-oxen, ? 26.
naila, shins, 6, 9, 11, 13, ? 14.
nanne, rascals, 8, 16.
nkwe, leopards, 3*, 9 f., 13*, 17.
nkwenyane (dim. of above), 3.
noko, porcupines, 22.
noga, snakes, 8, 18*, 19, 22 f.
ntwa, wars, troops, 23 f.
ntsho, black, 1 f., 7, 12.
ntwane, a little troop, 8.
ntshwabisa, those that grieve me, 16.
ngana (from a tree name), 4, 6-8, 10*, 11, 13*, 22, 24 f.

- ngo[a]naPelo, stout of heart, 23*.
 ngOpe, water-courses, 8, 17, 26 ?
 ngolo, goat with yellow belly ?, [10].
 notwane, little hammers ?, 22, 27.
 OpaThebe, those that drum on their shields, 15.
 oketsa, those that add, enlarge, 15.
 pula, rain, 26.
 phutha, gathering, 24.
 petu, necklets (? as part of uniform), 23.
 pena-pena, the vanguard, 16.
 petlwana, little adzes or skin-scrapers (so Brown, petlo), 9*.
 phaswa, dappled (black and white oxen), 23*, 15 (phatshwa).
Portuguese, 17.
 pondo, from "pound" on appearance of sovereigns, 9.
 pota, turning round, 11.
 pulana, a little rain, 1 f., 12*, 14.
 rataKgosi, loving the chief, 15 f.
 rataKgomo, loving the cattle, 16 f.
 ratwa, beloved (? latlhwa, *q.v.*), 3.
 rema, the woodsmen, 4, 6, 17.
 rema-ka-Cheka, felling with axes, 15.
 retela, smooth, or very hard; a regiment of baModimosana baMaTau,
 ? 1902.
 retlwa, the tree *Grewia cana*, do., ? 1918.
 me-rileba, raw meat or ? maiden, 5, 9*, 11 f.
 rutla, pull up (tree), 1*, 2, 3*, 14.
 robaMetlwa, breaking the thorns, 15.
rooi-Baanje, red-coats, *e.g.* of Major Warden, with whom baRolong
 allied against Moshesh, *v.* 24, or after British took over Tvl., *v.* 26.
 setlaoka, red ants, 16.
 sEpa, putting things straight, 23.
 s[h]otla-Kgosi, scorning a chief, 17, (18).
 sita[Kgosi], outstripping (the chief), 22, (24), 27.
 sitaPheho, outstripping the wind, 15.
 swene, monkeys, (10), 14.
 sonya, grinners, 7 f., 12 (=soswe in list 8).
 soswe (mo-soso, a tree), 8.
 sOkola, the passionate, 15.
sole (from soldiers, prob. in first Matebele War), 20.
 swele, burnt (and so fearing the fire, shirking; but perhaps swene), 10.
 senya, destroyers, ? 25.
 teane, meeting, 16.
 di-thaga, yellow finks, 3*.
 theoga, descenders, 26.
 thamaga, red ox with white back, 9*, 10, 13*, 14.
 thametsu, making an enterprise too hard for someone, 16.
 thiba, those that stop the way, 8, 14.
 tekEta, talkers, 1.
 thibaKgosi, stopping the chief, 22.
 thibaKgomo, stopping the cattle, 24.

thologa, overflowing, wasters, 19.
 tlhware, pythons, 18, 26.
 tlogela, forsakers (or tlh., shoots), 15.
 tlakane, devourers, 4, 7 f., 9*, 11-13, 17.
 tlatsa, helpers, 26.
 tladi, lightning, (1), 2, 3*, 4-6, 10, 12, 18.
 tlhaba, stabbers, 9, 13; tlh.-tau, stabbing the lion, 22.
 tlhaselwa, those attacked (? in *mophato* or circumcision lodge) by C.M.R., 23, 25.
 tlhwana, brown cows, 4 and 10 (if without *h*, snares ?).
 tlhola-Kgang, continuing strife, 16.
 tlhoma-Thebe, fixing shields, 16*, 23.
 thopa-Kgomo, raiders of cattle, 23.
 tlotlaKgosi, honouring the chief, 22 f.
 thubaNtwa, breaking up the host, 16, 22.
 thubaPula, rain, 23*.
 thul[w]a, the hammered ones (hammerers), (1*), 8 f., 11.
 tsaKgosi, taking the chief, 18.
 tsa[ea]Kgang, taking up strife, 17.
 tshela, leapers, 6 f., 9, 14 (? tsEla, very warm).
 tshelaPhala, leaping the buck, 16 f., 19*, 22 f.
 tsetse, fleas, 23.
 tsie, locusts, 14, 17.
 tsuba, burning, 14; ts.-Tlali, do., lightning.
 tuba, thumpers or "guts," 9*, (10*).
 tuku, flame, 8, 10.
 tswaKgotsa, those that come from court, 16.
 tshepe, men of iron, 6.
 tsosa, rietbok (? tshosa, hartebeest-bulls), 15.
 tsapa, hungry ones, 15.
 tla-kaMokgwa, coming acc. to custom, 26.
 tica, dappled (black and white spots), 16.
 tshela-Tau, leaping the lion, 18.
 tshola-Tau, lion-hunters, 18.
 tlholaLibe, spying out bad things, 19 f.
 ut[lw]aKgang, hearing (or tearing away) strife, 15.

N.B.—*O* and *E* are pronounced broad, *ng* as in *sing*, *c* as English *ch*, *ch* this aspirated, *tsh* as aspirate of *ts*.

The numbers refer to the *mephato* name-lists adjoined. When letters of the regiment name are bracketed (as sometimes omitted), the bracketed numbers and meanings omit them.

In the lists the small letter denoting each successive chief of a tribe is suffixed to the name of his own regiment, and prefixed to that of the first regiment indicated in his reign.

I shall be specially grateful for further information and lists from the following tribes:—baTauana of Ngami, багаMotlhwara, багаMananwa, баKwenaba-Kubung, and баFokeng, баPhalane, etc.; баPhiring, баTaung of Rustenburg, баNtwane, баNareng, баPo, баTlako and баModjadji and баMamabolo, and from the Kaffir and Rhodesian tribes.

1. BaTLHALOGA.	2. maGANANWA.	3. baTOKWA.	4. bagaMASIBI.	5. MASHISHANE.
a. Moshebudi b. Ramanyoba c. Mokgoba d. Seripa, reg. e. Soshigo f. g.	Lebogo Pulaboshigo Mathome, d. 80 Kgadushe	Ngwakomachibi " marema Musima Kunwana Sarani Motalahote, k. 85 Masanyane	Mapela, d. 25 gdson Mankopane, d. 77 Masibi, d. 90 Hans, d. 05 Marcus, regt. Alfred, ch. 17	
thwana*		c. 1750 rutla*		
...		phaswa ? ^b		
kgalwa		di-thaha ?		
rutla		nkwe ?		
thula		tladi ?		
fulaca		lat(l)hwa ? ^c		
keretla (teketa)		dingwane ?		
tica		hohu ?		
jaNku		rutla		
ntshob		phaswa ^e		
lau	ntsho	di-thaha	lekana ^b	
pulana	pulana	dingwana	ngana	
kgalwa ^d	kgalwa		*tlakana ^c , 77	
hlwana ^e , 73	koba	tladi ^z	hohu	
*tl(l)adi, 83	tladi	ratwa (lathwa), 76	bitse	
bitsi, 93		dingwana, 94	*tladi, 90	me-rileba
*thula ^e , 99		*'ohu, 98	lekana ^e	dingwane, 04
*rut(l)a, 00	rutla	rutla, 03	rema, 96	
	phaswa	phaswa, 07	dingwana, 04	
	kgau	di-thahankwe, 15	*tlhwana ^f , 12	tladi, 19
			*ngana, 18	
		baRAMOKGOPA		
		phaswa		
		tladi		
		nkwe		
		nkwenyana		

* I imagine that P. is the name o

5.	6.	7.	8.	9.	10.	11.
MASHISHANE.	baKEKANA.	bagaMATLALA.	baKGATLA. bagaKGAPELA.	bagaMAKAU.	baPEDI.	bagaMUTSHA.
		Matlala Mapiti Paledi Matou	After Molefe a. Pheto, ii b. Pilane c. Kgamananyane d. Lencwe e. Isang, heir f. g. h. j. k. l.	Moshe Motsepe Seamoge, d. 88 Moemise Alfred	Tulare, d. 24 Malekutu, k. 26 Sekwati, d. 61 (bros. kd. by Tebele, c. 30) Sekukuni, i, k. 80 Mampuru, ii, k. 83 Kgolokwe, d. 93 Makveteng, d. 04 Kgolokane and cozz. Malekutu, d. 04 Sekukuni, ii Padutle	
			?radipetsa thiba cecele fatshwana ^a dima gata chama firi ^b thulwa ngope ^b dingwane, c. 35 noga nanne, soswe ^c , kete-kete ^c ganelwa, ngana tuku (i), dima (fenya Ramphelana, 63 fatlha, 68 tlhakana ^d , 74 ^d koba, isaKoma, 80 jaNko, lalaMetlwa (lalla- Lira), -Abilwe, 84 f. ntwane, lwelaMotse, 91 f.	? c. 1780 cecele ^a petlwana tlakana ^b ^b thulwa, c. 22 thamaga me-rileba tuba kgwaliba ^c ?, 46 ^c golopo nkwe tlakana, dima gasa?, 65 tlhaba thamaga, pondo cecele galwa tshela, 88 ^d me-rileba, 93 tuba, 96 kgwaliba, 03 petlwana, 07 golopo, 10 naila, 13	[swene (These from Rev. N. Roberts) golopo tuba nala ngolo dikwa disa kgwa] tladi, 48 ? swele ^c kgobaf... ^d thamaga?, 63 ngane?, 69 kwa?, 73 tuba?, 77 dingwana [e]lima ^e ?, 81 ^f koba?, 85 tuku?, 89 ^g tlhwana, 93 ^h nkwe, 97 ^h ngana?, 00 gasa?, 04 swene?, 07 tuba?, 11 kgalwa	butswana lobela koba pota edima naila kwa?, 89 koba, 94 tlakana?, 99 me-rileba, 03 ngana, 08 thulwa, 17
me-rileba dingwane, 04		ntsho sonya ^b ... tshela ^c ... koba ngana hohu dingwana bitsi dima naila kgau, 08	aparaNkwe, kuka ila " 00 f. cecele ^e , 11 fatshwana, 15			
tladi, 19		tladi				

P. is the name of the present Inspector of Native Reserves, i.e. Purchase. (Note by the Rev. E. Sili, who collected this list.) The word usually means "peaches"
N.B.—Regimenta

10.	11.	12.	13.	14.	15.	16.
<i>baPEDI.</i>	<i>bagaMUTSHA.</i>	<i>baMOSETLHA.</i>	<i>baMPAHLELA.</i>	<i>baKWENA. baMAGOPA.</i>	<i>banaNGWATO.</i>	<i>baKWENA.</i>
ulare, d. 24 alekutu, k. 26 kwati, d. 61 ros. kd. by Tebele, c. 30) kukuni, i, k. 80 ampuru, ii, k. 83 goloewe, d. 93 akveteng, d. 04 goloane and cozz. alekutu, d. 04 kukuni, ii adutle		Nchaupe Matsapane bro. Mathibe, d. 99 son Salatiel Solomon	Matsobane Mutle Matsobane Mutle Patule	Sekwati Mamogale Lerothodi John More	After Mathibi a. Kgame, i b. Kgare c. Sekgome d. Kgame, ii e. Sekgome, heir f. g. h. j.	After Legwafana Mocwasele Seitlamo Legwale Mocwasele, k. 22 Sechele, d. 93 Sebele, d. 11 Sechele, d. 18 Sebele, ii
wene (These from Rev. blopo N. Roberts)						kgwa?, 1750 thametsu lalaMetlwa ^a godiri godimo ^b ² kgwa tlhomaThebe ^c gata firi ^d ...
iba ala golo ikwa isa gwa] adi, 48 ? wele ^e gobaf...					tlola?, 1780 robaMetlwa jwetshepe ^a thula ^a lupe rema-kaCheka bhapoga utlwaKgang opaThebe sitaPheho lomaKgomo lekaNtwa ^e rataKgosi, 40 folosa ^d , 4 tsosa, 56 lwelaMotse, 64 emelwa, 07 alola, 70 ^d oketsa, 74	^d lalaMetlwa?, 08 tshelaPhala teane penapena do., ^e c. 30 ^e ganelwa, 38 nanne, 42 ganaTsatsi, 47 thubaNtwa ^f , 56 tlholaKgang, 62 ganaMokgwa, 66 ntshwabisa, 70 rataKgomo ^g , 77 lwelaKgosi, 81
hamaga?, 63 gane?, 69 wa?, 73 uba?, 77 ingwana kldima ^a ?, 81 oba?, 85 uku?, 89	butswana	pulana ... fatlha, 68	nkwa?, 34 thamaga ngana ^b ^b tlakana gasa ^c dingwana ^c chedi kgalwa	Kgari tsuba pulana jakgomo rutla tshela gana kgomoca ganelwa thiba tsie jane ^d , 96 ^d swene, 99 thamaga, 02 (naila, 06)		^e ganelwa, 38 nanne, 42 ganaTsatsi, 47 thubaNtwa ^f , 56 tlholaKgang, 62 ganaMokgwa, 66 ntshwabisa, 70 rataKgomo ^g , 77 lwelaKgosi, 81
lwana, 93 kwe, 97 agana?, 00 asa?, 04 wene?, 07 uba?, 11 galwa	koba, 94 tlakana?, 99 me-rileba, 03 ngana, 08 thulwa, 17	tlakana tladi pulana sonya, 08	hlaba dima naila thamaga ngana ^d , 00 ^d nkwe, 15		phatshwa?, 87 kgobaMotse, 89 tlogela, 97 tsapa, 04 sokola, 15	letaNtwa, 88 tlhomaThebe, 96 kakasetlaoka, 01 tlogela, 04 thubaNtwa, 11 rataKgosi ^h , 15 twaKgotsi, 17

ed this list.) The word usually means "peaches" (W. A. N.). Mr. Silk also mentions that one *legakgomo* was living in Nov. 1920. That regiment was therefore no doubt
N.B.—Regiments in list 27 without brackets are of the baMaidi. All except the italicised names are those of Ganyesa (Bolong?).

16.	17.	18.	19.	20.	21.	22.	23.
WENA.	baTLOKWA.	bagaMALETE.	baNGWAKETSE.	baHURUTSE. bagaGOPANE.	do. багаMOILWA.	bagaMOTLHWARE.	baROLONG.
Legwafana vasele mo ale vasele, k. 22 le, d. 93 e, d. 11 le, d. 18 e, ii	After Bogacwi Kgosi, k. 23 Matlapeng Gaborone Molefi, hr.	After Powe Mokgosi Ikaneng, d. 02 Mokgosi, d. 17 Seboko	After Moletsek, 90 Makaba, d. 24 Sebego, d. 37 Senthuthe Gaseitsiwe, d. 89 sonBathweng, d. 10 sonSeepapico	Diutluleng, d. 23 Mokgatla Lencwe, d. 36 Gopane, d. 04 Mokgatle a Lencwe Samuel	a. Moilwe, d. 75 b. Sebogodi, d. 77 c. Ikalaheng, d. 94		After TSIID a. Thutlwa, b. Tawane, c. Montsiwe d. Wessels e. Badirile f. John, dep g. Letlamore
?, 1750 tsu etlwa ^a ob Thebe ^c etlwa?, 08 Phala ena e c. 30 va, 38 42 satsi, 47 Ntwa ^a , 56 Kganga, 62 lokwa, 66 abisa, 70 gomo ^a , 77 gosi, 81 wa, 88 Thebe, 96 etlaoka, 01 t, 04 Ntwa, 11 gosi ^b , 15 gotla, 17	tlakana ^a gata (v. No. 8) betlwana hiri (v. No. 8)? do. chame ngope do. ^b rema ganelwa ^c tsa'Kganga gwasa goiwa <i>Portuguese</i> eakaThata, 78 ganaKgomo llelaKgosi rataKgomo, 85 tsie, 90-2 aparaNkwe, 00 Komponi, 07 shotlaKgosi, 11 lwelaMotse, 15 f. ilaMotse?	? fitlhaKgosi ? Powe's do. ? tlhware ^a ... a|pofhi noga tsholaTau tshelaTau tsa'Kgosi ^b jaPoho tlhware tladi eakaKganga, 74 eakaNtwa ^a fitlhaKgosi eakaPula lwelaMotse, 98 eakaThata sotlaKgosi ^d , 10 tlholaDibe	eakaNtwa gwasa thologa ^a noga gaga do. (c. 23-25), prob. before 1820 lau ^b abaKgomo lekaNtwa ^d ?, 30 tlholaDibe gataKgomo eakaThebe ^c lokwana losaNkwe isaNtwa ^e ?, 65 tlotlaKganga, 75 eakaThata, 82 eakaPula, 87 tshelaPhala, 96 lau, 01 tlwelaNaha, 08 lwelaKgosi, 16 lataKgosi, 19 ^b (sitaKgosi, 19)	 abaNtwa lwelaMotse, 75 ganelwa?, 85 <i>sole</i> , 93 ganaMokgwa, 96 [tsaakgang] eakaNtwa, 02 ^b fitlhaKgosi, 04 eakaKganga, 01 f. <i>German</i> , 14	 isaNtwa isaKgosi eakaNtwa abaTonatona eakaThata ganaMokgwa fenyaKgosi disaKgosi	noga batane tshelaPhala notoana kodisa caga tlhabaTau gataKgomo gaiKgomo nokoana losaTlou thibaNtoa (kubaN.) ganena tlhoare sitaKgosi tlotlaKgosi dibaMotse nenaPula henyaKgosi chubaTladi mokaee yaChupa gaenaKganga letaPene sica-ka-Lotlhaka noko <i>Perekini</i> * sepala	dila?, 1760 tshelaPhala sepa ^a gwasa chologa noga no[a]naPelo gaga ^b thubaPula ^b galaTladi tshelaPhala lau?, 1820 abaKgomo nto[a] ^c , mets no[a]naPelo, gataKgomo, tlhomaThebe thopaKgomo ^c lokwana, 54 tlotlaKgosi, disaKgomo, disaKgomo tselset ^d , 60 godu, 72 petu, 78 f. tlhaselwa ^e , 8 ganelwa, 98 eakaThata, 0 eakaKgosi, 0 lwelaKgosi? filaKganga, 1 ? betlaKganga lataKgosi

Therefore no doubt circumcised well within the nineteenth century, even as late as 1840, *Matshelaphala* before 1820, and *Manoga* (cp. baNgwaketae and baRolong) near 1800. (??).

18.	19.	20.	21.	22.	23.
<i>baga</i> MALETE.	<i>ba</i> NGWAKETSE.	<i>ba</i> HURUTSE. <i>baga</i> GOFANE.	do. <i>baga</i> MOILWA. <i>baga</i> MOTLHWARE.		<i>ba</i> ROLONG.
After Powe Mokgosi Ikaneng, d. 02 Mokgosi, d. 17 Seboko	After Moletsek, 90 Makaba, d. 24 Sebego, d. 37 Senthuthe Gaseitsiwe, d. 89 son Bathweng, d. 10 son Seepapico	Diutluleng, d. 23 Mokgatla Lencwe, d. 36 Gopane, d. 04 Mokgatle a Lencwe Samuel	a. Moilwe, d. 75 b. Sebogodi, d. 77 c. Ikalaheng, d. 04		After TSIDI a. Thutlwa, d. c. 1800 b. Tawane, d. 51 c. Montsiwe d. Wessels e. Badirile f. John, dep. 19 g. Letlamoreng

	<i>eaka</i> Ntwa gwasa thologa ^a noga gaga do. (c. 23-25), prob. before 1820				dila ?, 1760 tshelaPhala sepa ^a gwasa chologa noga no(a)naPelo ? ^k gaga ^b thubaPula ^b galaTladi tshelaPhala throughout b lau ?, 1820 abaKgomo nto[a]f, metsaPhala, 28 no(a)naPelo, 11, 34 gataKgomo, 38, or tlhomaThebe, 44, or thopaKgomo, 51 ^c lokwana, 54 tlotlaKgosi, 57 disaKgomo, i, 61 disaKgomo ii, 63
tlhware ^a ... lpofhi noga tsholaTau tshelaTau isa'Kgosi ^b jaPobo tlhware tladi <i>eaka</i> Kgang, 74 <i>eaka</i> Ntwa ^c <i>fitlha</i> Kgosi <i>eaka</i> Pula lwelaMotse, 98 <i>eaka</i> Thata sotlaKgosi ^d , 10 tlholaDibe	lau ^b abaKgomo lekaNtwa ^d ?, 30 tlholaDibe gataKgomo <i>eaka</i> Thebe ^c lokwana losaNkwe isaNtwa ^e ?, 65 tlotlaKgan, 75 <i>eaka</i> Thata, 82 <i>eaka</i> Pula, 87 ^e tshelaPhala, 96 lau, 01' lwelaNaha, 08 lwelaKgosi, 16 lataKgosi, 19 ^b (sitaKgosi, 19)	abaNtwa lwelaMotse, 75 ganelwa ?, 85 sole, 93 ganaMokgwa, 96 [tsaakgang] <i>eaka</i> Ntwa, 02 ^b <i>fitlha</i> Kgosi, 04 <i>eaka</i> Kgang, 01 f. German, 14	isaNtwa isaKgosi <i>eaka</i> Ntwa abaTonatona <i>eaka</i> Thata ganaMokgwa fenyaKgosi disaKgosi	noga hatane tshelaPhala notoana kodisa caga tlhabaTau gataKgomo gaiKgomo nokoana losaTlou thibaNtoa (kubaN.) ganena tlhoare sitaKgosi tlotlaKgosi dihaMotse nesaPula henyaKgosi chubaTladi mokaee yaChupa gaenaKgang sietPene siet-ka-Lotlhaka noko Perekisi * sepala	tsetse ^d , 60 godu, 72 petu, 78 f. tlhaselwa ^e , 85 ^d ganelwa, 98 ^e <i>eaka</i> Thata, 04 <i>eaka</i> Kgosi, 07 lwelaKgosi ?, 10 ^f laKgang ^g , 14 ? betlaKgang lataKgosi

within the nineteenth century, even as late as 1840, *Matshelaphala* before 1820, and *Manoga* (cp. *ba*Ngwaketae and *ba*Rolong) near 1800.

	24. baSELEKA.	25. baRAPULANE.	26. baTAUNG. bagaMATLAKEU.	27. baTLHAPING.
DI a, d. c. 1800 e, d. 51			a. Mosomi, i b. Thapuse, d. 93	After 1830 a. Mankurwane b. son Molale, d. 1920 c. son Hendrik
re s e ep. 19 oreng	h. Koikoi j. Moroka k. Sefunelo, d. c. 30 l. Moroke m. Tshepinare n. Samuel	o. Molekane p. Makgwe q. Matlabe r. Shwedintle s. Ramolekana	c. Gasebone, 93-6, 2-13 d. Sehume, 96-02 e. Mosome, ii, d. 13 f. Molatlhegi	
0 a				
lo ?k				
a throughout baRolong (cf. 16, f. 19) ?	ngana abaKgomo ntwa do. jaKgomo ^m eakaThebe rooiBaaitje gata, thihaKgomo ? busa ^b fenya ? jaPoho ?	ngana abaKgomo jaKgomo ntwa ilwa ? senya ^f busa gata alosa tlhaselwa ^c ganelwa, 97 letaKgosi eaka or apaPula kgare, 06	? gwasa ^a ? nare ? ngope lokwanab, 75 fikang, 79 rooiBaaitje gang, 82 tlakaMokgwa ^c , 85 disaKgomo ^c , 89 fitlhaKgosi, 93 nosi, tlatsa ^f , 00 etheoga, 06 tlhware, 09 fpula, 12 ganelwa, 16	(hachane) ("gou-kom"), 36 abaNkwe (gaeKgomo) ngana lasu jaTaub jaKgomo (notwane) lo-haha d(henyaKgosi) mogolodi, 85 ganelwa sitaKgosi, 96 tlotlaKgosi, 02 f. thibaKgosi henyaKgosi ^c letaKgosi, 14 eakaThata (anon.), 18
85				
8, 04	sita			
07	gasa			
? , 10	gapela			
14	phutha, 16			
g				

SESUTO AND SECHWANA PRAISES.

By the Rev. Professor W. A. NORTON, M.A., B.Litt.

If we allow a wider meaning to literature, and make the term cover all art-forms of the spoken language, we at once obtain a whole range of such. Open, for example, Carl Meinhof's volume on the poetry of the African at the title-page, and you will find the fairy tale, myth, saga, epic, hymns and embryo drama, proverb and riddle and song, enumerated as examples of what I mean. If these examples fall mostly below the literary level, in the way of bulk, of our European poets and dramatists, the same can by no means be said (in the matter of finish) in the case of many of the royal praises, delivered at dawn from the edge of the acropolis rock of some chief in his praiser's stentor voice, and re-echoed among the boulders which strew the stad or *astu*. I had never realised the full meaning of the Greek city state, with its central town and citadel, and but scattered villages beside, through wide territory, till I saw the stads of the chieftains Sebele and Lenchwe in Bechwanaland. The acropolis of the latter is an enormous pile of rocks, like Pelion on Ossa, approached by a most narrow winding path, tangled with bush.

To turn back from such chiefs to their bardic literature (if I have successfully made good its claim to the term), of which they are in their kind, like Alcinous of old, the patrons, let me illustrate the *lithoko* (or praises), which to my mind have something of the heroic type of Homer's epic. To test this statement one needs, of course, to have an appreciation of them in the original: let me give first an attempt to render the spirit of them in English verse, and I will choose the famous story of Lethole, the material for which was gathered by my old friend the Resident Commissioner of Bechwanaland in the days when he was still in Basutoland. Lethole, chief of the Makhoakhwa in Basutoland (early nineteenth century), had hired Zulus to help him attack the brother of the famous chieftainess Mantatise. He refused them their share of the spoil, but they caught him later and sentenced him to death. He begged them first to let him sing his own praises for the last time, and they stood listening.

Spellbound stood his foes
Listening to the death-marked warrior :
Off, off he goes,

Like an arrow from the bow-string,
Shoots amid the throng,
As they stand aghast a moment,
Then raise a song :

They a song far other-sounding,
Snarl of cheated beast :
Start the men, and dart the heavy
Spears, seeking feast.

Fast they fly, but he flies faster
Over field and fell,
Yet one fleetest than the others,
With dart so fell,

Reaches him, all but outracing
That tremendous shot :
Reaches and his back transpierces :
Blood outbursts hot :

Down it streams, but he pants onward,
Coughing out red spume,
Recking not his ebbing vigour,
Counts but the room

That he sets between the bloodhounds
And his flying feet :
Once he turns—far off they follow,
Less fleet . . . less fleet . . .

So he staggers down the burn-bank
To the water's edge,
Shelter'd from those grim pursuers,
Hid in the sedge.

For a moment he emerges
On the opposing bank :
Once again his strength he urges—
Slow, slow he sank,

Pouring out his latest blood-stream
As the warriors came,
Singing with last breath the praises
Of his doughty name.

(Southern Cross, May 1915.)

No. 1. Lethole's song was kindly supplied to me by Mr. J. C. Macgregor, C.M.G., Resident Commissioner of Bechwanaland, when A.C. of Leribe. It runs as follows :—

Lethole le thunyang, Le thunyang khomong tsa batho,	L. the <i>Dust</i> (archaic for <i>Lerole</i>), which shoots up among people's cattle,
La re ho thunya, la apesa pelesa.	when it shoots up, it covers the beasts.
Hlabeli, tlola Rakhabane a bone ; A bone, ha ho qhalangwa menaila.	H. (<i>i.e.</i> L.) leap, that R. may see, may see when the vanguard have been dispersed.
Khwahlan'a maroba	A strong man of the maroba (L.'s circumcision mates).
Mokhaloli-qenatsan'a maroba, Mokhaloli ba o hlobile sesela, O ts'o tjkela o le feela.	M. (a bird white and black) [tail ; you singing bird, they pulled off your you sing without it (<i>i.e.</i> have no pride).
Hlabeli tswetse ea se itja mohlana.	H. as a cow just calved ate the after- birth.
Bashanyana ba llela sekaqa. Ha lla Posho le Lenyolosa. Mohlankana oa qhoba nku ka letolo, Hlabeli, Khomoe tshwana ea ngwan'a Lechesa	the boys cried for a lump of it, there cried P. and L. the young lad H. drives sheep by the lightning, the black cow of Lechesa's child
E tsamale ea sehlaka matsika Mor'a Lechesa kolobe li ea jana, Kolobe li ea jana Bolaoaneng, Ka mona ka ha likubu matshaneng.	went and beat the M. (<i>i.e.</i> Maroba ?) Son of L. the pigs eat each other. They eat each other at B., Here in these little lakes in the hippos' place.
Lefuma (-o ?) le kwana haMahemane, Ha rwesa mekoli khomo e tehehali ;	Poverty (? wealth) is at M.'s : Bunches of beads are tied on a cow (? a maiden).
Thokwana ea rwala shwahla mola- leng.	The fawn-coloured cow had plenty (of beads) on her neck.

To end the Sesuto part of my paper, I give No. 2, an ordinary improvisation of a South Mosuto boy praising himself (Mogapunyaana of Vereeniging, son of Masopha, a Motloung of Basutoland) :

I am the brindled one of Ramatsikitlinyane,
The child of the wife of Khwali :
Take the ox's horn, and pluck it earthward,
Let the lads run with it.
They said : " The black kine are not lean,
But in summer they trouble us ever."
I picked the bat off the willow tree,
I trod in a slippery place and slid :
I came forth carrying the men's shields in a pile :

I slaughtered the lamb, and divided it among the elders.
 But the lamb choked one of the aged ones. . . .
 Then he took the dipper to the stream,
 That he might drink and swallow.

(Contributed by Legabo of Cape Town.)

The original is as follows :

Ke nna Thamanyane ea Ramatsikitlinyane (i.e. leopard)
 ngwana wa mosali wa Kgwali :
 nka lenaka o le kgolele fatshe,
 bashemane ba le nke motiitii.
 Ba itse "Tse ts'wana ha li ote
 empa lehlabula li hlote li re khathatsa."
 Ka thwalla maborokoane fateng sa Moluane,
 ka hata lereli ka thella :
 ka tswa ke sikere lithebe tsa banna sekwankwetla :
 ka hlaba konyana, ka ea ka e abela maqheku :
 eaba konyana e khama leqheku ;
 eaba le kakalatsa liho ho ea nokeng,
 ho ea theosetsa nama.

No. 3. A seTaung piece :

Lesá, buabua lechabana :
 Mosali o lebetse Lekete RaMpioane,

O lolobetse a ea tlung.
 A ba a tsoha ka meso a le hleka.
 Lesá, u hlomme thebe thoteng :

Bashanyana, le se ke la e ts'oara,
 Ke thebe ea molisana Selemo.
 Lelothoane, mphahle, ke ee holimo,

Ke ee bona likhomo tsa moka'n'a me.
 Ka kena kahare, ka otlá lekaba

Le maoto a meleka.
 Se ntshoere, Phakoe-e-tshoenyana
 Ea selemong ha Motsetse.

Nonyana ena, ho thoe'ng, ke Ra-
 Potietí ?

Ke re, ke e romme mollo ka morung :
 E ne e fihla e qhonokha molomony-
 ana.

L., tell a varied tale :
 the woman hath forgot Lekete, the
 father of Mpioane,
 She goes straight to the house :
 but she rose early and bright (pure).
 L., you have planted the shield on
 the hill :

Lads, touch it not,
 it is the shield of Spring the herdboy.
 Salvifolia, let me brush past thee and
 go up

to see the cattle of my mate.
 I entered within, I smote the ox (to
 be slaughtered at his marriage)
 with a crooked shin.

It seized me, little white hawk
 at the precipice (of the Viervoet) at
 M.'s place. (M. was headman of
 the village at Orange Springs, near
 Modderpoort, O.F.S., and grand-
 father of Enea, now dead, who
 supplied the piece).

Why is this bird named R. ?

Then I sent it for fire to the forest.
 It was pursuing up its sulky little
 mouth.

Though these are not a chief's praises, I insert them as another example of the poetic effort which is constantly being put forward by native bards, professional and otherwise.

I will now pass to the praises of the Bakgatla chiefs, and begin with those of Kgamanyane, the father of Lencwe, and those of his father and grandfather. This was that Kgamanyane who was sjamboked before his people by Herklas Malan, the veld-kornet of Rustenburg, as related to me by the widow of the chief, daughter of the great Moshesh. I find myself wondering whether the veld-kornet's friends commemorated his work as worthily from the literary point of view as the people of the man he sjamboked. At any rate, the incident should remind us that, as there was another side to the heavy-handed official of the "Bushlice"—for such was the elegant soubriquet which these praises fasten upon the steadfast foretrekkers (doubtless they had others for the rooinek, and even the missionary)—so there was another side to the *ou kerel* or *schelm* to whom, as he thought, he was administering due chastisement, for complaining, on behalf of his people, of the hardness of the tasks they were set to. It will be remembered that the Boers demanded labour from the natives in return for the protection of their better arms against the raids of Moselekatse. Hence the difference of opinion. To the honour of the Dutch Church be it said that, to this day, even the independent Bakgatla of Bechwanaland retain their mission among them, in spite of their disagreement with the Dutch of the Transvaal as their political overlords.

The Praises of Kgamanyane the sjamboked run thus :

No. 4 :

Kgapetla e tlhaba-tlhabañ thata a	Sharp-piercing shard of the royal
Masoswe a Kgosiñ,	Masosoe (kg.'s own regiment),
o se re o tlhaba ea ekete o tlaletswe,	smite not as though in anxious
	uncertainty,
etswe le metlheñ, o se ke o tlallwa.	perchance sometime thou'rt anxious:
	be not so.
Makgalimotse o sefega sa nkwe,	Fast-striding M. with the leopard-
	crest (or breast),
o kgeleli ea tau,	with the lion's scar,
mogats'a Likolo a Ramontsana-tlou.	Spouse of L., Ramontsana-tlou's
	daughter ;
Tubá tubá ea Makhinya-khinya-	(praise-name of Kg.)
khinya,	
eare he le tsamaea,	When he walks,
tlhako se kgopa se senwe sa	One shoe strikes against the other
lekhinya.	of Lekhinya :
Lekobela le tsoga kwa leñoleñ.	but the supple knee-bender rises
	from the knee.

Kwa seleteñ go ñwana o monana,	Where the good land is, there's a new (born) child (<i>i.e.</i> Kg., <i>cp.</i> Pollio),
go legora le lieletsa Molefi le rago- Mojalefa.	there is the hedge to protect Molefi and the father of the Heir (<i>i.e.</i> R'lane).
E ne e-na le Ramolibe tshukulu,	The rhinoceros (Kg.) was with Ramolobe,
tshukulu ea ga ka le Ramorontse, care e fitlha fa Mankwe, ea tlhapa, ea ja taka, ea boea ka matsogo, ea ba ea boea ka likgokono, tshukulu ea ga ka le Ramorontse.	my rhinoceros and Ramorontse's. When it arrived at Mankwe, it swam, it ate lime, which came up its arms, Yes, it came even to his elbows, (the elbows) of my rhinoceros and R.'s.
Magoapitlana, ñwana-mahulu wa ga Kgafela,	Walker like the tortoise, Ñwana- mahulu of Kgafela,
ñwana mahulu, tshaba tlhaga : O le mañ ?	Child of the tortoise, shun the dry grass, for who are you ?
O le lifako li nkwele gale,	You are the hail which has fallen on me longsyne :
tlhagana tsa marallana.	You are the small dry grass of the hills.
Motho, ke tshaba wa selepe ; wa molamu ga ke mo tshabe : a ka re " tou," ka hunyela, ka hunyella legapeñ.	" Man, I fear him of the axe. him of the kerrie I fear not : he may smite, but I pull in my head : I pull my head into my shell !"

Nearly every line is crammed with allusions like the lines of a Greek chorus or a Hebrew prophet, and those who cannot follow much of them must allow for their effect. I hope, however, something of it may be given even in my rough version. It is very much that of the blessing of Judah or Benjamin in Genesis :

Judah is a lion's whelp :
From the prey, my son, thou art gone up :
He stooped down, he couched as a lion,
And as a lioness : who shall rouse him up ?

Benjamin is a wolf that raveneth :
In the morning he shall devour the prey,
And at even, he shall divide the spoil :

or that of Joseph in Deuteronomy :

The firstling of his bullock, majesty is his :
And his horns are the horns of the wild ox :
With them he shall push the peoples, all of them.

No. 5. I add the praise of Pheto, grandfather of Kgmanyane :

Ke Ramopyane a baKgatla, ke tshukulu ea ga Mpheteñ : ke eme.	I am R. of the Bakgatla, the rhinoceros of Mpheteng, let me be !
Pheto a Molefe, ke ratwe ke batho. (ke ratwa ke mme Moliane) :	P. son of Molefe, I am loved by none (save by my mother M.).
ke tshukulu ea ga Mpheteñ, ke eme. Ge le sa mphete, le-tlhola-lillo,	I am the rhinoceros of Mpheteng. Let me be ; if you do not pass me by, bringer of lamentation.
ke tlholla bomaeno go beolwa.	I do make your mothers to be shorn for grief.

The last line refers to the quaint custom by which bereaved women shave the head, as in Bible times, except for a tuft or tasselling of hair strings from the middle of the crown, having at a short distance the effect of a football cap. The Praise concludes :

Ramopyane, o se be o tshwaetse :	R. maybe thou hast made an end (of a wounded man).
kgosi ga e tshwaele, e nna fela :	'Tis not for a chief to do so : he lets be :

(Repeat these two lines, adding ga Raseakanyo = at R.'s place ['tis so].

These of Pheto's son Pilane complete the series of three generations :

No. 6 :

- (1) It is Pilane, the rock of the anvil stone, the slippery one :
Those who touch it will leave their fingers,
And that Mabine has proved.
I am Pilane that makes to war (ke P. a malos) a)
The beast of Kopong and the wood of Litlhotlhe.
(Selo se mo K . . . L.)
- (2) The common Folk are poking at his hole and annoying him :
The beast has been annoyed by Mmamorogoana of the Mabulisa (vassals
of the baKgatla).
He is thrusting forth his head, he pecks savagely,
And returns to his place Kopong. . .

The original runs :

- (1) Ke Pilane, ke tlhapa la ntswe pilwane, ke lethapa
le le boreleli Pilane : ba le tshware, ba tla
tlog[el]a menwana : le tshwerwe ke Mabine, a tloga meno.
(For the rest, v. *Dico*, p. 77.)
- (2) Ba lintlha ba nntse ba se gwaisa, se gwaisitswe
ke Mmamorogwana oa BaMabolisa, se ne se ntsha tlhogo, se ba
thObonya, se boea se boela kafa Kopon, se
kafa Kopoopoon, kafa Litlhotlhe. Tau makunya a ga
ba-Phalaphala, etc., as in Mr. Wookey's *Dico*, p. 78.

The last lines (from Tau . . .) may be rendered :—

The roaring lion of the flood of peoples,
Descending from the smooth rocks of the monkeys,
Roaring and hastening to divide the spoil.
When he arrived at Selitlwe,
He roared, and then silenced his voice,
This lion of the Hyenas.

(Pilane's circumcision regiment were called the Hyenas, *maFiri*.)

After this my informant adds :

Ñwaketse babeli bale ba kgopywa ba wa, ba kgopywa
ke ese ke be gaufi : etlare go le ke atamela Pilane,
rumo le tla nwa mali a Setate, ntsi e tla nwa
bobete, Pilane, segeñ ga Ñwaketse a Morara ntweñ.

This means :

Those two BaÑwaketse are trembling and fall before
I could be near. Now, when I Pilane approach,
the spear shall drink Setate's blood, and I Pilane,
as a fly, shall drink his gore, in a lake at the
place of Ñwaketse, descendant of Morara—in battle
(in which Pheto has sent his son P. to aid the
Bakwena. Setate is a Ngwaketse).

No. 7. Sekgatla Praises by Seatile Meshake Lebotse, praising himself :

Ke rile ka bopyoa senare, ka ba ka bopyoa setau, moroa kgosi ;
When I was formed, I was formed with the nature of the wild ox and the
lion, a King's son ;

phatlana ea nna mokgeletsanyana, meritsana ea ea le litomego :
my forehead has a groove, with the hair following the cupping-mark :

ke palame kota ka bala motse ka re : “ Se ga se motse, motsana.
I climbed a tree-stump, I took stock of the Stad, and said : This is no
town, but a village :

Ntoa e ka tla nasuta, e ka suta : ke apere metja, ke ila lerole
War may come nigh, yea, come nigh.” I put on my kilts, I shun the dust

ka makutung, ke sa gate lefatshe, ke ila le motho a nkgoma
from the feet ; nor do I kick up the earth, I shun the touch of men

ke feta, ke be ke tsitsibane, ke be ke batle go omana,
in passing, I condemn, and am apt to curse,

potepote le motho, ke mmolae, ke mo tseela thebe.
and to chase one in and out, that I may slay him, and may take from him
his shield.

Lithebe, re ne re sa li pege, re ne re li kgoagetsa feela
The shields, we never hang them up, but just within reach we hitch them,
re li pega mo mopiping. Ke nna mosimane oa Mokongoana oa Mamokoena
oa Seroka.
hanging upon the pipe tree. I am the youth of M. of Mamokoena's house,
the daughter of S.

(The penultimate sentence means the weapons are always ready.)

No. 8. Setoutoe's Praises of Senelo, his grandfather, who went with the
Mafiri regiment to Ngwato (being himself a *lelima*), saying :

Ke e'o bona koa bana ba ea teng. I am going to see where they are going.
Mamalima o ja ka legetla, o ja ka perepe ea legetla. Moth'o itaea ka
patla oa
Mamalima eats with a shell, she eats with a big spoon of shell. A man
hits with

Malima, o othibosetse chaba, li tla be li go lemoga, baSeame ka baRatlhagana.
the stick, he of the M. (regt.) he prevents the enemies coming to gaze at him,
both baS. and baR. (in B.P.).

Ba re, "A! merafe ea Boroa e bilioa fela, e le mapshega : A ! e bilioa fela.
They say that the nations to the South (from Tvl.) are simply cowards. Ah !

(b) Ga le 'mone a Molefe (i.e. Senelo) : ga le mmone, o bapile le lona :
You do not see M.'s son, he is by your side :

a ea tshoga ka e le kgoelo e kgoeloga botlhatsana :
it happened, as he darted from the bush,

Mogale a phofa tsa kgaka, Mogale a liphofa,
the hero of the kgaka's wings, the guinea-fowl feathers suit him well,

li ea mo tshoanelatshoanetse, mogats'a Nketso a Kgetse. (Note the rhyme.)
the husband of N., child of Kg. (Senelo killed his cousin, also a hero : there-
fore called Kgoelo the darter. Both were leaders of the Matlhako.)

We pass from Lencwe's people to the Bakgatla ba Makau, between
Rustenberg and Pretoria. Moewise (b. c. 1845, father of the present chief)
and his brother Molikwe were sons of the old chief Leamoge, called in
Dutch, for good reason, Sjambok ! (1828-88).

No. 9. Sereto sa Seamoge :

Kgomo e tshopho ke golile,	I am an'ox with spots and am grown,
lilekana, ke golile, ke luma makg-	the spots are equal, I am so big, I
wata	roar wherever I go (or hoarsely).

I insert the interpretations given locally, even when I am not satisfied
with them. I also preserve spelling as given, which is often an index to
dialectical phonetic.

No. 10. Molikwe's Praises :

Phekola ea sebata, moloko oa banna, ga te itse go leka :	Charm of a beast, I belong to virile men, I know not to attempt :
ñwana oa Matlhali ka tsa bogale,	a child of the M. regiment that came with valour,
ba nchupetsa mankwe : ñwana kanthe kgwali kwa bosa eabo ga li fele. ke phuphutla thamaga,	a man that can fight with tigers, child that is like a partridge in the morning when it trips along. I prod the red and white ox (after which one of the regts. was called).
moshemane o tswetsweñ le Moemise. Phata ea likgwali ka gobala,	the boy that was born with M. I was wounded (but still went on, with my wound, fighting).
phatagali likgwali ka gobala.	striped with great wounds like a partridge.

No. 11 :

Mo Thubatse motho o tswañ mo tlhake[ñ]	There at the Steelpoort River is the man that comes forth from the reeds, the reedbed
motl[h]ak'a morota wa masebutla sa limo :	of the kloof of him who can face giants :
motho wa bolabola, moloñwana wa maitsibolla :	the man talks and talks, the little mouth that talks first :
o seba ga le mmone, go sa le [le-] phetha a le tjeki.	he reproaches, but you do not see him, he is like a bead so small (you do not see it on the ground).

We now turn to the North Bakwena, and first we have the praises of Mocwasele II (killed c. 1820).

No. 12 :

Pholoholo ea Bo-tlhapa-tlou, ea noka ea Metse-motlhaba, ke e tsetlha,
The beast of the elephant-bath of the river of troubled waters is yellow,

ee metse e li matla : e tlhotse e gwelelwa ke lichaba, e gwelelwa,
whose mane is stiff : the livelong day it is shrieked at by the tribes,

e phamotse maralu. Lira tsa ga Kgari linyana ?
it seized the milch kine. Are the foes of K. (old Kg. of Nwato) few ?

a fha lira li roba magolelo,
when the foes crush the herbs,

fha temoñ ea ga Ramatokwane ?
in the garden of R. ?

Nna le boPolile re bo-ebeñ :
I. and P.'s men are in a quandary

re lebalanye :
and forget each other (? lebelanye, look at each other).

fhala le mo pineñ :
only you are in the dance :

pelo go setse go utlwagala
in the heart there still is heard

mogatlhare wa ga Tsamaa-gotlhe,
the chatterer who goes everywhere,

Raseitlhamo aKwena
Seitlhamo's sire and Kwena's son (*i.e.* Mocwasele II.).

No. 13. Praises of Sechele I, son of Mocwasele II (a plea for the reception of the baHurutse, baKgatlā, etc., when fleeing from the Boers in 1852) :

Re na le motho, o Neokencoke :	We have a man N. (the Subtle, <i>i.e.</i> Sethele).
Eare fa lekwalo le tla le befle,	If there come a letter with bad talk,
Le eene a kwale la gagwe, a re :	He also writes his letter, and says :
Tsa[e]a, o le ise, Masholobotlho,	Take it and carry, M. (S.'s old servant).
Batho se bao : a ga ba bone barwa rrabo BaHurutse ?	Here are people : don't they see their friends the BaH. ?
Batho ba ea re[ng] ba[a] noa kofi,	(There are) people who, when they drink coffee,
Ba ba nee morogo ba o nwe.	give them (baH.) dregs to drink.
Shupegetsā ba-bina-kgabo botshelo,	Show mercy to the monkey-dancers (<i>id.</i>).
Ba tle ba tshale ka wena :	That they may live by thee !
Ba go thele * madi a kgofa (ba fete mogocoana),	To bring on thee blood of the Bush-louse (<i>i.e.</i> Boer)—Let them pass the cupping bowl.
E be e re dimo a sale a ya wena nosi.	Let the cannibals (<i>id.</i>) eat thee up alone.

N.B.—The baTlokwa, baHurutse, baGaManana (sometimes ranked with the baKgatlā), baGaMalete, baGaMokibilu, and baTlhako all took refuge with the baKwena under Sechele from the Boers.

No. 14. Lesike's Praises of Sebele I, fighting the Bamangwato under Macheng (soon after 1860), at Kgama's request :

Kwena matuduanye wa ga Sechele,	The diver crocodile of Sechele (fr. of Sebele),
Matuduanye wa ga rraSebogiso,	The diver of Sebogiso's sire,

* *Thela*, seKwena dialect for *tshela*, to pour (broad *e*; with shut *e*, means to live = *phela*).

o tlhakantse batho le Matebele,	Confounded the folk, even the Matebele,
Eare ba lebile ditima-modimo,	When they beheld the Ditima-Modimo (? regiment).
A bo a e-tla a tlaola Matebele,	He came and cut down the Matebele,
A bola[e]ja, a ba latsa mmetha :	Killed them, laid them in heaps :
Ka ba ka tlhoma ke re " Kwena " :	And then, I had said " Kwena " :
Ka khutla, ka bua se sele, ka re :	I stopped and spake otherwise :
" Tsankole, pholoholo,	" Quick little jumper of a steen-bok,
Ea setlhabela-manong,	The beast the vultures stab,
Manong a a kwa Mabele-a-podi,	The vultures of Teats-of-the-goat (Mtn.),
A re a fhofha, a fhofha, a khubidu,	The red vultures, which fly, fly,
A ya thata ea ga Phometsi-a-kwena,	Which eat the power of the Unafraid (Prover of Leviathan),
Ea ga matuduanye wa ga Sechele,"	Of the diver of S.
Matuduanye wa ga rraSebogiso.	The diver of S.'s sire."
Merachwanyana ea Serowe,	O ye small tribes of S. (Kgama's present stad),
Masilo a ntshitse matlhwana a mo lebile :	M. gazed on him with all his eyes :
" Kgama e tla bona kae botshelo ? "	" The Hartebeest, how will it live ? "
E kile ea raka Kwena letsibogo :	It crossed the river before the Kwena came :
Moseya ole o mfhera,	The further side it is very narrow :
O thata :	'Tis hard :
Ba tla tshwarwa ke mfhera-mangole.	They will be caught by the knees.
Ke Nao-dintlha wa ga Mocwasele,	I am the active one of M.,
Nao-ditelele wa kgosi,	The long-footed one of the chief.
Mosii mosii wa dira,	And overtaker of the foe :
Mokgarametsege Malope (? Molope)	The forward Malope (little bird with long tail).
Metseng ea batho	In the cities of men,
Fha gare Mahutagane le Kurwe.	Among the narrow places and at K.
(Both in the east of the Bakwena country).	
Batho ba tshabile tladi ea makau,	The people feared the lightning of the youths.
Ba tshabile tladi ea boMashamatse,*	They feared the lightning of the men of Mashamatse.
Pholoholo ea boGañwañwe (Seb.'s sister).	The beast of Gañwañwe's folk :
E se gadima lwa bo-Motshwane a Mmatle,	'Tis the lightning of the men of Motshwane (son of Mmatle).
La Makatapitse a ga Botshabelo.†	Of the Makatapitse regiment of the Stronghold.

* Elder brother of Baruti, Sebele's cousin. Most of the names are of members of the Bakwena royal family.

† Sechele's stad as a city of refuge for the tribes mentioned in No. 13, note.

Se dule se nakaletse selemela, S'wa godimo, soo Kgosisintsi	The Pleiads are out and shine, They fall from above, they are on K.'s side,
Le Seadiñwana a Mocwasele :	On Seadingwana's, Mocwasele's daughter :
Se o'le, go sa ntse go itebetswe, Fha gare ga mebilana ea batho Ea ga Mangwato le ea Bokalaka. Le-pha-batho la boKgabo le Kgakge, La dikgosi : dikgosi boMotswane a Mmatle Bokgaimena la Legoyane : Nfhere wa diphoholo le batho, O kile o kile wa patika boThthankane.	They fell unexpected * Among the streets of men In Mangwato and Karangaland. The disappointer of Kgabo and Kgakge's men, Of the chiefs, the chiefs of the party of Motshwane, Mmatle's sons, Of Kgaimena and Legojane ; One who broke both beasts and men, and once pressed the folk of Ththankane.
Bagamangwato, lo tlhasetswe eng ? Lo tseneletswe ke'ng ? Maamong lo tseneletswe ? Ke le-tlhanega batho, ke kolwane la Matlhorangwe :	O ye Mangwatos, what attacked you? Ye were approached by what ? In your steads invaded ? 'Tis the Leaver-of-men-dead, 'tis the youth of the man that sits but little.
Sebele ke lekatapitse la (? loo) Tumagole : Ke tlhoruñwa ea boKgari, a Sechele.	S. is a <i>lethubantwa</i> of Tumagole, He is the rained-on grass of Kgari's men (son of Sechele).
O e-tla, le-bola[e]ja, le-go rebola, wa ga Sechele : O e-tla : a bola[e]ja, a ba a lesa : Ke ra[e]ja, gobo a lesitse Moatswae,	He comes, the slayer, yet to deliver even Sechele's son : He comes : he slew, again he spared. I say it, in that he spared Moatswae (a Mongwato),
A lesitse MorwaKgomo, a reboga.	He spared Moatswae (son of K.), and delivered him.
Kwena, mogolole, ke ea go leboga,	Kwena, my elder brother, I thank thee,
Ka go bolaea le go rebola : Kgosi o jaffhile seng, wa lesa Ma- thubi ? Kgosi e busa ka bana ba merafhe !	For slaying and for sparing ! How well didst thou, chief, when thou sparedst M. The Chief rules by the sons of the nations (spared by him).

No. 15. Another Praise of Sebele :

Mochacha mogakatsa-mala, More mojew-a-o-botlhoko : O ka jewa ke monna a sa o itse, O ka mo tshwara, wa mo kgobola mmele, mere ea tla ea fela, re ee pele ;	Bitter herb, which poisoneth within, Physick bitter in the taking : Should it be eaten by one unknowing, It should seize him, bruising his body, And medicine would not suffice, though to hand,
---	--

* Is this passage connected with Donati's comet, 1858-9 ?

ha fela boshokwe le bomakgoro-
metso, Neither boshokwe nor bomakgoro-
metso.

Kgomo e lela kwa Phapane,
e lela e re "Sebele we!" The ox lows at Phapane (Hill).
e tlholetse bo-Ngwato go senyeha. It lows and says "Sebele."
It caused boNgwato to be de-
stroyed. (Oxen are the usual
native *casus belli*.)

Me a thutlwa tse ke tsa molapo wa Are yon giraffes those of Sefoka'
Sehoka? vley?
a di neilwe Phoka? Have they been given to Phoka?
Ga di tshwarwe, Nay, they are not to be caught,
le ha kgomo tsa bangwe di tla tshaba, Even if the cattle of others flee,
di tlogele marole mo tlotleng. And leave their calves in the ruins.

No. 16. Yet another Praise of Sebele :

Mashweu-shweu ao a ya (ao) Those white men are eating up
tlou tsa Mothathe, masepela phalo : The elephants of M. They are those
who outstrip in their going,
Tlou li kile tsa etela Sebele, eo o The elephants paid a visit to Sebele,
Sechele; Sechele's son.
o tsetsoefgjo fhenya lichaba; He was born to rout the nations.
re raea ka a fhetlha Mokmakaneñ; We mean because he pierced to M.
le ga maNwato, o tla go fhitlha : and at maNgwato shall he arrive :
me eare fha kgomo tsabo li gapiloe, and when their cattle are taken,
a bile, a samile cheka, he made a war-axe his pillow,
Mogats' a Motshipi. that spouse of M. (? Sebele I.'s wife).

No. 17. Leboko la ga Mpelege (by himself on his deeds in the Kwen-
Kgatla War, '75-9) :

Batho ba yelwe ke Hauhau-koma : Men are eaten by Hauhau (i.e. with a
crackling of bones)—'tis a secret :
Ba yelwe ke tlhone rea tlhabana. They are eaten by sadness as we fight.
Ka erile re se na ho tlhabana ntwā, When we had fought our war,
ra ba ra tlhonama ra nna fela. we were sad and sat still.
Tloga, o ba abe, morwa Mocwasele, Arise, O son of Mocwasele,
o ba abe, and marshal them with the youths :
O ba abe le makau : a swift one (i.e. Mpelege) tries the race.
sefatelele se leka macomane. He is patient, the child of Mmopi :
O pelo-kgale, ñwana wa ga Mmopi : He is patient, he shall lay men low.
O pelo-kgale, o tla digela batho. I have seen him in the war with the
Ke mmonye ka ntwā ea ha Kgafela. Kgafela.
O digetse banna ba le bantsi : Surely he hath laid low many men :
Tsela-e-mang o re, leke a mo etsa, T. saith he will try to do likewise,
A tla a tsena mo ganong g'a dilo, g'a and get him into the mouth of the
di-ya-batho. beasts, of the man-eaters.
(Ke khutla foo Mpelege.) (The words of Mpelege are ended.)

* Close to Pilane aiding.

NOTE ON A DETERMINANT WITH FACTORS LIKE THOSE OF THE DIFFERENCE-PRODUCT.

By SIR THOMAS MUIR, F.R.S.

1. The determinant in question, when of the 3rd and 4th order, is

$$\begin{vmatrix} 1 & a+b & ab \\ 1 & b+c & bc \\ 1 & c+d & cd \end{vmatrix}, \quad \begin{vmatrix} 1 & a+b+c & ab+ac+bc & abc \\ 1 & b+c+d & bc+bd+cd & bcd \\ 1 & c+d+e & cd+ce+de & cde \\ 1 & d+e+f & de+df+ef & def \end{vmatrix},$$

the scheme of construction being readily grasped when the scheme for the first row and the scheme for the second column have been observed. Clearly it is such that when of the n^{th} order the number of variables occurring in any row is $n-1$, and the total number of variables is $2(n-1)$.

2. Recalling the effect produced on a determinant by reversing the order of its rows, we see that the function under consideration, F say, is at most altered only in sign when the order of its variables is reversed : for example,

$$\begin{aligned} F(a\ b\ c\ d) &= -F(d\ c\ b\ a), \\ F(a\ b\ c\ d\ e\ f) &= F(f\ e\ d\ c\ b\ a). \end{aligned}$$

3. Performing on the 4-line determinant the operations

$$\text{row}_1 - \text{row}_2, \text{row}_2 - \text{row}_3, \text{row}_3 - \text{row}_4$$

we obtain

$$\begin{aligned} F(a\ b\ c\ d\ e\ f) &= - \begin{vmatrix} a-d & (b+c)(a-d) & bc(a-d) \\ b-e & (c+d)(b-e) & cd(b-e) \\ c-f & (d+e)(c-f) & de(c-f) \end{vmatrix} \\ &= -(a-d)(b-e)(c-f) \cdot F(b\ c\ d\ e), \\ &= (d-a)(e-b)(f-c) \cdot F(b\ c\ d\ e), \end{aligned}$$

where it will be observed that the three factors on the right are got by, as it were, subtracting

from the row $d\ e\ f$
the row $a\ b\ c$,

and the F on the right from that on the left by removing from the latter its first and last variables.

Exactly similarly it is found that

$$F(a b c d e f g h) = (e-a)(f-b)(g-c)(h-d) \cdot F(b c d e f g),$$

and we thus finally reach

$$\begin{aligned} F(a b c d e f g h) &= (e-a)(f-b)(g-c)(h-d) \\ &\quad \cdot (e-b)(f-c)(g-d) \\ &\quad \cdot (e-c)(f-d) \\ &\quad \cdot (e-d). \end{aligned}$$

4. The marked resemblance of this development to that of the alternant

$$| a^0 b^1 c^2 d^3 e^4 |$$

cannot but strike the student, the factors in both cases being all *differences*, and the number of them in the one case being the same as in the other. We are thus led to expect that the said alternant is derivable from $F(a, b, \dots, h)$ by specialization; and such is readily found and shown to be the case. For, returning to the development at the close of the preceding paragraph, and putting

$$f, g, h = a, b, c$$

we obtain

$$\begin{aligned} &(e-a)(a-b)(b-c)(c-d) \\ &\quad \cdot (e-b)(a-c)(b-d) \\ &\quad \cdot (e-c)(a-d) \\ &\quad \cdot (e-d). \end{aligned}$$

$$\text{i.e. } (-1)^6 \cdot (b-a)(c-b)(c-a)(d-c)(d-b)(d-a)(e-d)(e-c)(e-b)(e-a),$$

so that our result is

$$F(a b c d e a b c) = | a^0 b^1 c^2 d^3 e^4 | = \zeta^4(a b c d e).$$

5. An interesting alternative mode of proving this last equality is to show that

$$F(a b c d e a b c) \cdot | a^0 b^1 c^2 d^3 e^4 | = | a^0 b^1 c^2 d^3 e^4 |^2.$$

Taking for shortness' sake determinants of the 4th order we have

$$\begin{aligned} &\begin{vmatrix} 1 & a+b+c & ab+ac+bc & abc \\ 1 & b+c+d & bc+bd+cd & bcd \\ 1 & c+d+a & cd+ca+da & cda \\ 1 & d+a+b & da+db+ab & dab \end{vmatrix} \cdot \begin{vmatrix} a^3 & -a^2 & a & -1 \\ b^3 & -b^2 & b & -1 \\ c^3 & -c^2 & c & -1 \\ d^3 & -d^2 & d & -1 \end{vmatrix} \\ &= \begin{vmatrix} (a-b)(a-c)(a-d) & & & (d-a)(d-b)(d-c) \\ & (b-c)(b-d)(b-a) & & \\ & & (c-d)(c-a)(c-b) & \\ & & & \end{vmatrix} \\ &= - | a^0 b^1 c^2 d^3 |^2; \end{aligned}$$

and consequently the multiplicand

$$= - | a^0 b^1 c^2 d^3 |.$$

It is also just worth noting that the one determinant can be directly transformed into the other, the first step of the process being to perform on $F(a b c d a b)$ the operation

$$\text{col}_2 - (a+b+c+d) \text{col}_1.$$

6. Besides the specialization

$$f, g, h = a, b, c$$

there are a number of others resembling it although of less interest: for, without causing the function to vanish, we may put

$$\begin{aligned} f &= a \text{ or } e, \\ g &= a \text{ or } b \text{ or } e, \\ h &= a \text{ or } b \text{ or } c \text{ or } e; \end{aligned}$$

for example,

$$F(a b c d e e e) = (e-a)(e-b)^2(e-c)^3(e-d)^4.$$

7. Of far greater interest, however, is a specialization of a different kind, namely, that which leads to a new determinantal representation for the product of the binomial sums of a, b, c, \dots . It is well known that for representing such a product as

$$\begin{aligned} &(a+b)(a+c)(a+d) \\ &\cdot (b+c)(b+d) \\ &\cdot (c+d) \end{aligned}$$

there is no form analogous to the alternant, and that in fact when the said product does occur in determinantal analysis it appears as a quotient, namely,

$$| a^0 b^2 c^4 d^6 | \div | a^0 b^1 c^2 d^3 |.$$

8. Going back to the result of § 3 and altering the signs of the second triad of variables, we obtain

$$\begin{aligned} F(a, b, c, -d, -e, -f) &= (-d-a)(-e-b)(-f-c) \\ &\cdot (-d-b)(-e-c) \\ &\cdot (-d-c) \\ &= (-1)^3 \cdot (d+a)(e+b)(f+c) \\ &\cdot (d+b)(e+c) \\ &\cdot (d+c); \end{aligned}$$

and similarly for all other orders of F . In other words, By altering the

signs of the second $n-1$ variables in $F(a, b, c, \dots)$ all the differences in the factorial development of F are changed into sums.

9. From this as an immediate consequence we have

$$\begin{aligned} F(a, b, c, -d, -a, -b) &= (d+a)(a+b)(b+c) \\ &\quad \cdot (d+b)(a+c) \\ &\quad \cdot (d+c) \\ &= \text{product of the binomial sums of} \\ &\quad a, b, c, d: \end{aligned}$$

and similarly for every other such product. We can thus formulate the theorem that *If in the new determinantal equivalent for the difference-product of n quantities we alter the signs of the second $n-1$ variables in the functional symbol, the resulting determinant is equal to the product of the binomial sums of the said n quantities*: for example, from the equality of § 4

$$F(a, b, c, d, e, a, b, c) = | a^0 b^1 c^2 d^3 e^4 |$$

we deduce the companion equality

$$F(a, b, c, d, -e, -a, -b, -c) = | a^0 b^2 c^4 d^6 e^8 | \div | a^0 b^1 c^2 d^3 e^4 |.$$

10. There is an entirely different way of viewing the product of binomial sums, namely, as the eliminant of a pair of equations in x . Taking, for example, the equations

$$\begin{aligned} (a+b+c+d+e)x^4 + (abc + \dots + cde)x^2 + abcde &= 0 \\ x^4 + (ab + \dots + de)x^2 + (abcd + \dots + bcde) &= 0 \end{aligned}$$

where the coefficients are sums of combinations of a, b, c, d, e , it is not difficult to show that their eliminant is the 10-factor product

$$(a+b)(a+c) \dots (d+e) \dots \dots \dots (E)$$

One sure basis for proof lies in the fact that, if we multiply both sides of the second equation by x and perform addition we obtain

$$(x+a)(x+b)(x+c)(x+d)(x+e) = 0,$$

and that the substitution of any one of the five roots of this derived equation in the two original equations changes their left-hand members into the product of four of the factors of E . Another basis of proof is the fact that if in the original equations we put one of the ten factors equal to 0, say $a+b=0$, the equations are transformable into

$$\begin{aligned} (x^2+ab)\left(x^2+\frac{cde}{c+d+e}\right) &= 0 \\ (x^2+ab)(x^2+cd+ce+de) &= 0 \end{aligned}$$

and are thus seen to be consistent.

The latter mode is less readily generalizable than the former. To give an indication of the line it takes, it may be stated that in the case of 7 variables the original equations

$$\begin{aligned} (a + \dots + g)x^6 + (abc + \dots + efg)x^4 + (abcde + \dots + cdefg)x^2 + abcdefg &= 0 \\ x^6 + (ab + \dots + fg)x^4 + (abcd + \dots + defg)x^2 + (abcdef + \dots + bdefg) &= 0 \end{aligned}$$

are transformed into

$$\begin{aligned} (x^2 + ab) \{ (cdefg)_1 x^4 + (cdefg)_3 x^2 + (cdefg)_5 \} &= 0 \\ (x^2 + ab) \{ x^4 + (cdefg)_2 x^2 + (cdefg)_4 \} &= 0 \end{aligned}$$

where, be it remarked as a digression in passing, the trinomial factors in the left-hand members are exactly similar to the left-hand members of the pair of equations with which we started this paragraph.

11. As a natural consequence of the result here foreshadowed we are led to consider the dialytic eliminant

$$\begin{vmatrix} 5_1 & 5_3 & 5_5 & . \\ 1 & 5_2 & 5_4 & . \\ . & 5_1 & 5_3 & 5_5 \\ . & 1 & 5_2 & 5_4 \end{vmatrix}$$

where

$$\begin{aligned} 5_1 &\text{ stands for } a+b+c+d+e, \\ 5_2 &\dots ab+ac+\dots+de, \end{aligned}$$

and so on.

Multiplying it column-wise by unity in the form

$$\begin{vmatrix} 1 & . & . & . \\ -e & 1 & . & . \\ . & -e & 1 & . \\ . & . & -e & 1 \end{vmatrix}$$

and then multiplying row-wise the resulting product by unity in the form

$$\begin{vmatrix} 1 & . & . & . \\ e^2 & 1 & . & . \\ e^4 & e^2 & 1 & . \\ e^6 & e^4 & e^2 & 1 \end{vmatrix}$$

we reach the result

$$\begin{vmatrix} 4_1 & 4_3 & . & . \\ 1 & 4_2 & 4_4 & . \\ . & 4_1 & 4_3 & . \\ . & 1 & 4_2 & e^4 + 5_2 e^2 + 5_4 \end{vmatrix},$$

the elements taking the simple form here given by reason of the equality

$$5_m - e5_{m-1} + e^2 5_{m-2} - \dots = 4_m.$$

Since the last element

$$\begin{aligned} e^4 + 5_3 e^2 + 5_4 &= e^4 + (e4_1 + 4_2) e^2 + (e4_3 + 4_4) \\ &= e^4 + e^3 4_1 + e^2 4_2 + e4_3 + 4_4 \\ &= (e+a)(e+b)(e+c)(e+d), \end{aligned}$$

and its cofactor is our dialytic eliminant of the next lower order, it is clear that we shall have finally

$$\begin{vmatrix} 5_1 & 5_3 & 5_5 & \dots \\ 1 & 5_2 & 5_4 & \dots \\ \cdot & 5_1 & 5_3 & 5_5 \\ \cdot & 1 & 5_2 & 5_4 \end{vmatrix} = \begin{aligned} &(e+a)(e+b)(e+c)(e+d) \\ &\cdot (d+a)(d+b)(d+c) \\ &\cdot (c+a)(c+b) \\ &\cdot (b+a), \end{aligned}$$

as was expected.

12. A less pleasing but more quickly effective mode of proof would be to attest the existence of any one of the linear factors, say $d+e$, by showing that the putting of $d+e$ equal to 0 in the determinant causes the latter to vanish. Or, again, we might perform the operation

$$\text{col}_4 - d e \cdot \text{col}_3 + d^2 e^2 \cdot \text{col}_2 - d^3 e^3 \text{col}_1,$$

when we should find that the 4th column as thus altered contains the factor $d+e$.*

RONDEBOSCH, S.A.,
4th May 1922.

* Apparently the first to observe this peculiar bigradient was Mr. A. M. Nesbitt. See *Educ. Times*, lvii (1904), p. 490.

COLOUR AND CHEMICAL CONSTITUTION.

PART XVII.—THE AZO DYES AND OTHER MONOCYCLIC COLOURS.

By JAMES MOIR.

Some preliminary work on the azo dyes appears in Part XII of this work, pp. 215–216, accompanied by the remark that the problem appeared hopeless of solution. Since then, by examining all the related simpler substances, I have discovered a method of calculating their colours, and thus uniting them to the monocyclic class already discussed in Part XIII.

The examination of the simpler substances could only be done by photography. Other colour chemists will therefore join me in thanking Mr. E. R. Grills (of Hortor's Ltd., Johannesburg), who presented me with a diffraction-grating specially mounted on a thin cover-glass such as is used in microscopy: this instrument enabled me to photograph down to λ 320 and thus find the absorption of many colourless substances which required to be examined in order to discover the theory of the azo dyes. The fact that I had to use a glass (not quartz) lens prevented a complete investigation further down in the ultra-violet. This I hope to attack later on.

Remarkable to say, the very first photograph I took with the new apparatus gave a discovery. Alkaline paraoxyazobenzene in water was the substance the spectrum of which was photographed, and the negative showed not one broad band at λ 420, as previously supposed from visual observation (Tuck, J.C.S., London, 1907, diagram on p. 450, and Moir, *loc. cit.*), but *two* distinct although overlapping bands at $\lambda\lambda$ 433 and 395. Further investigation showed that *all* the members of the family show this phenomenon: sometimes, as in acid butter-yellow, both bands are very distinct, and sometimes they are so overlapped that only a faint luminosity appears in the middle and the band looks at first like a single very broad one; in such cases the estimate of the centres of the two bands is quite uncertain, being in doubt by more than five units.

Again, all the substances are indicators and change colour if made acid or alkaline, thus giving three kinds of spectrum according to the

reaction of the water in which they are examined. As all the absorption-bands are double, each substance has six bands in all, and it is the object of this paper to calculate all the six bands of each substance.

This leads to the result that each of the six bands corresponds to a different chemical constitution, or at least to a different orbital motion of an electron round the molecule.

As examples, *p*-oxyazobenzene has $\lambda\lambda$ 433 and 395 when alkaline, $\lambda\lambda$ 490 and 463 when acid, and $\lambda\lambda$ about 340 and 315 when neutral, the corresponding figures for butter-yellow being $\lambda\lambda$ 490+460 and 543+508 and about 405+375. Taking the former example, the six chemical constitutions are respectively: Ph . NH . NOH . C₆H₄O', Ph . NOH . NH . C₆H₄O', Ph . NHCl : N . C₆H₄OH, Ph . N : NHCl . C₆H₄OH, Ph . NH . N : C₆H₄ : O, Ph . N : N . C₆H₄OH.

SOLUTION OF THE PROBLEM OF THE OXY-COMPOUNDS.

Let phenate-ion, C₆H₅O' have λ 287 in water.*

Let the α -methylene-interposition-colour-factor, -CH₂-, be 0.92.

Let the α -imino- " " " -NH-, be 1.09.

Let the β -methylene- " " " . be 1.15.

Let the β -imino- " " " . be 1.22.

Let the α -oxidation-factor be 1.10.

Let the β - " " " . . . 1.035.

Let the α -phenyl-substitution-factor be . . . 1.135.†

Let the β - " " " . . . 1.03.

Then we have all the data for calculating the bands of the oxy-compounds of azobenzene, azomethine, stilbene, benzaldehyde, benzhydrol, benzophenone, diphenylamine, triphenylcarbinol, phenylhydroxylamine, etc.

The method of calculation is, as before, factorial. All the relative factors taken from the formula of the substance are multiplied together, the result being the wave-length of the band-centre corresponding to that formula. For example, Ph NH NOH C₆H₄O' gives:—

287 (phenate) \times 1.09 (α -imino) \times 1.10 (α -oxidation) \times 1.22 (β -imino) \times 1.03 (β -phenyl), which equals 432.4, the decimal part having no significance on account of the factors being correct only within one-half per cent.

In order to simplify the subsequent calculations, some of the factors may be multiplied together to begin with, thus giving useful subsidiary factors.

Thus: α -carbinol, CHOHa, = 0.92 \times 1.10 = 1.01

β - " CHOHB, = 1.15 \times 1.035 = 1.19

* Observation agrees with this.

† As found before in Part XIII, A, of table on p. 36.

α -oximino, NOHa,	$= 1.09 \times 1.10 = 1.20$
β - „ NOH β ,	$= 1.22 \times 1.035 = 1.26$
β -benzyl, PhCH ₂	$= 1.15 \times 1.03 = 1.185$
β -Ph . CHOH	$= 1.19 \times 1.03 = 1.23$
β -anilino, PhNH	$= 1.22 \times 1.03 = 1.255$
β -Ph . NOH	$= 1.26 \times 1.03 = 1.30$

The above example, one of the bands of alkaline *p*-oxyazobenzene, now becomes: $287 (\text{phenate}) \times 1.20 (\alpha\text{-oximino}) \times 1.255 (\beta\text{-anilino}) = 432\frac{1}{2}$. The other band, from the formula $\text{Ph NOH NH C}_6\text{H}_4\text{O}'$ is got from: $287 \times 1.09 (\alpha\text{-imino}) \times 1.30 (\beta\text{-phenyloximino}) = 407$. The former agrees exactly with observation, but the latter is a little too high. The reason why the spacing and overlapping of the pair of bands varies has not been discovered.

We will now proceed to calculate all the oxy-compounds, beginning with the simplest.

1. The $\alpha\text{-CH}_2$ group put into phenate gives *p*-cresolate: calculated λ 264 (or $287 \div 0.92$). Not observed in water, λ about 285 in alcohol (Baly and Ewbank).

2. The $\alpha\text{-CH}_2$ group taken out of quinomethane gives ionised quinol: calculated λ 315 $\frac{1}{2}$ (or $290 \div 0.92$) for $\text{HO C}_6\text{H}_4\text{O}'$: alternatively phenate \times oxidation-factor 1.1: not observed.

The following table exhibits the rest of the results:—

Name.	Basis of Calculation.	Calculated λ .	Observed λ .
<i>p</i> -oxybenzaldehyde .	Quinol \times CHOHa .	319	330 (alc.).
<i>p</i> -oxybenzophenone .	Foregoing \times Pha .	362	Agrees visually.
<i>p</i> -oxybenzylalcohol .	Phenate \times CHOHa .	290	See Part XIII.
<i>p</i> -oxybenzhydrol .	Foregoing \times Pha .	329	"
Fuchsone .	Foregoing again \times Pha .	374	380 (alc.).
<i>p</i> -oxydiphenylmethane	Cresolate \times Pha .	300	
<i>p</i> -oxytriphenylmethane	Foregoing \times Pha .	340	
<i>p</i> -aminophenol .	Phenate \times NHa .	313	
Quinone-imine .	" \times NOHa .	344	About 355 (ether).
Quinone-anile .	Foregoing \times Pha .	390	Agrees visually.
<i>p</i> -oxydiphenylamine	Aminophenol \times Pha .	355	
Quinone-oxime .	Quinol \times NOHa .	379	397 (NaOH aqueous).
<i>p</i> -oxyazobenzene A .	Phenate \times NOHa \times PhNH β	432	433.
" B .	" \times NHa \times PhNOH β	407	395.
<i>p</i> -oxybenzalaniline A .	" \times CHOHa \times PhNH β	364	About 375.
" B .	" \times CH ₂ a \times PhNOH β	343	About 345.
<i>p</i> -benzalaninophenol-A .	" \times NOHa \times PhCH ₂ β	407	400.
" B .	" \times NHa \times PhCHOH β	384	About 375.
<i>p</i> -oxystilbene A .	" \times CH ₂ a \times PhCHOH β	323	} 329 not separated.
" B .	" \times CHOHa \times PhCH β	344	

In addition the monocyclic phthaleins may be calculated, using the CO_2H factor of Part XIII: the results are the same as in Part XIII and agree with observation. Other unobserved but calculated substances are: $\text{PhCH} \cdot \text{CH} \cdot \text{C}_6\text{H}_4\text{O}'$ (calc. λ 356), $\text{Ph} \cdot \text{N} \cdot \text{N} \cdot \text{C}_6\text{H}_4\text{O}'$ (calc. λ 447),

$\text{Ph}_2\text{N} \cdot \text{CHOH} \cdot \text{C}_6\text{H}_4\text{O}'$ (calc. λ 375), and $\text{Ph}_2\text{C} : \text{CH} \cdot \text{C}_6\text{H}_4\text{O}'$ (calc. λ 339 double). Almost all the possible substances have thus been considered.

Note.—The bands of the *acid* solutions of the oxyazo and oxyazomethine dyes are calculated * by multiplying the above-calculated (alkaline phase) bands by the factor 1.13, and the bands of the *neutral* phase by multiplying by a factor which is about 0.8. All the six bands of each substance are thus calculated.

MONOCYCLIC AMINO-COMPOUNDS.

The calculation of these is simply made from the oxy-compounds by multiplying by the factor 1.18 for acid solutions, the factor for $\frac{\text{NH}_3\text{A}}{\text{OK}}$.

For neutral solutions the factor $\frac{\text{NH}_2}{\text{OK}}$ is about 1.05.

TABLE OF CALCULATED AMINO-COMPOUNDS (ACID).

Name.	Calculated λ .	Observed λ .
<i>p</i> -toluidine salt . . .	$264 \times 1.18 = 312$	
<i>p</i> -aminobenzaldehyde . . .	377	Agrees visually.
<i>p</i> -aminobenzophenone . . .	427	Probably exceptional.
Aminobenzylalcohol . . .	342	} See Part XIII.
Aminobenzhydrol . . .	388	
Fuchsonium salts . . .	440	430.
Aminotriphenylmethane . . .	401	
<i>p</i> -phenylenediamine . . .	370	
Quinone-diimine . . .	405	About 370 (ether).
Aminodiphenylamine . . .	420	
Quinone-phenyldiimine . . .	460	488 and 450.
<i>p</i> -nitrosoaniline . . .	448	410 vague.
Aniline yellow A . . .	512	520.
" B . . .	480	485.
Aminobenzalaniline A . . .	430	About 440.
" B . . .	405	About 415.
Benzalphenylenediamine A . . .	480	} 465 broad, probably double.
" B . . .	453	
<i>p</i> -aminostilbene A . . .	381	
" B . . .	405	
Amino-azoxybenzene . . .	527	

* See the Table at the end for the observations.

MONOCYCLIC DIMETHYLAMINO-COMPOUNDS.

The multiplying factor for $\frac{\text{NMe}_2\text{HA}}{\text{OK}}$ is 1.25, i.e. for acid solutions. For the neutral phases the factor is 1.13, i.e. the bands of a *neutral* dimethylamino substance are practically the same as those of the corresponding oxy substance examined in *acid* solution (see previous page).

TABLE OF CALCULATED DIMETHYLAMINO-COMPOUNDS (ACID).

Name.	Calculated λ .	Observed λ .
Dimethyl- <i>p</i> -toluidine . . .	330	
<i>p</i> -dimethylaminobenzaldehyde . . .	399	About 380 and 355.
Dimethylaminobenzophenone . . .	452	Probably exceptional.
Dimethylaminobenzhydrol . . .	411	About 405.
Dimethylaminobenzyl alcohol . . .	363	
Dimethylfuchsonium salts . . .	466	460.
Dimethylaminotriphenylmethane . . .	425	
Dimethyl- <i>p</i> -phenylenediamine . . .	392	
Dimethyl-quinonediiimine . . .	429	About 400.
Dimethylaminodiphenylamine . . .	445	
Dimethylphenylquinonediiimine . . .	488	
Nitrosodimethylaniline . . .	474	457.
Butter-yellow A . . .	542	543.
" B . . .	509	508.
Dimethylaminobenzalaniline A . . .	508	513.
" B . . .	480	482.
Benzaldimethylphenylenediamine A . . .	455	460.
" B . . .	430	427.
Dimethylaminostilbene A . . .	430	
" B . . .	403	375.
Dimethylaminoazoxybenzene . . .	559	
Dimethylamino-stilbenoxide . . .	445	
Dimethylamino-benzophenoneanile . . .	524	

There are still many blanks in the observations, it being almost impossible for one investigator to repeat all the work which has stretched over the last thirty-five years; but the calculations cover nearly all the possible monocyclic compounds of this class.

Quinone Compounds.—Quinone in water has a band at λ 455 or 460 (centre vague), but cannot be observed in alkaline solution, i.e. as $\text{HO} \cdot \text{O} \cdot \text{C}_6\text{H}_4 : \text{O}'$ on account of oxidation. Assuming, however, that the water solution is ionised, we calculate the α -oxo-interposition factor to be about $457 \div 315\frac{1}{2}$ (quinol) or 1.45.

Quinonedioxime (in excess NaOH, as it is a very weak acid) has a sharp, strong band at λ 366, and quinonemonoxime in alkali a band which is

roughly intermediate between those of quinone and its dioxime. This gives a ratio O/NOH of 1.15 experimentally, whereas the ratio $-O/-NOH-$ is $1.45 \div 1.2$ or 1.21. Alternatively, quinonedioxime calculated from $HO-NOH \cdot C_6H_4 \cdot NOH \cdot H$, or from $NO \cdot C_6H_4 \cdot HNOH$, should have λ 412 instead of λ 366, so that it is necessary to make some distinction between the two groups attached to the benzene ring.

The old terms *chromophore* and *chromogen* involve two elements and a double bond and are now out of date, since, as I have shown in the first paper of this series, colour may arise merely from the attachment of two groups to a ring, the whole being oxidised.

I propose the new term *hapton* * for the second element and its attachments, reserving the old term *auxochrome* for OH , NH_2 , $NHalk$, and $Nalk_2$ restrictively. The *hapton* is intended to be a general term for C , N , O , or S .

Such a substance as sodium phenate, consisting of a ring and an auxochrome but no hapton, has not a strong absorption visible in great dilution (say $N/40,000$) as the true colouring-matters have. Technically it is a *coloured substance* with an absorption-band in the ultra-violet. Its pentabromo substitution-product is yellow, the 'loading' having raised the absorption-band from λ 287 to about λ 365, but the absorption-band is still not strong.

Now let a hapton be added, giving in the unoxidised condition $CH_3C_6H_4O'$, $NH_2 \cdot C_6H_4 \cdot O'$, $HO \cdot C_6H_4 \cdot O'$, $SH \cdot C_6H_4 \cdot O'$. These still remain *coloured substances*, not *colouring-matters*. They are leuco-compounds, with only shallow absorption.

Parahydroxybenzaldehyde is the simplest true *colouring-matter* giving a strong, sharp absorption-band even in high dilution. We thus require for a colouring-matter a ring, an auxochrome, and a hapton, and the whole must be oxidised. It is best to adopt an agnostic attitude as to the nature of the oxidation. The formula $HO \cdot C_6H_4 \cdot CHO$ refers to solid neutral hydroxybenzaldehyde, but the coloured aqueous alkaline solution may be $O' \cdot C_6H_4 \cdot CHO$, $O : C_6H_4 : CHO'$, $O \cdot C_6H_4 \cdot CHO'$ and half a dozen other formulæ involving the valencies of the ring itself.

Apparently the relation of the hapton to the auxochrome may be either ortho, meta, or para, but the bands of meta-compounds appear to be less pronounced.

The term *dye* is restricted to colouring-matters which stick to fabrics or mordants, e.g. phenolphthalein is not a dye.

* Cf. haptophore in bacteriology.

MISCELLANEOUS OBSERVATIONS ON AZO-DYES AND AZOMETHINES.

1. Ortho-hydroxyazobenzene (alkali)	. . .	$\lambda\lambda$ 441 and 390.
2. " " (acid)	. . .	λ 480 broad single.
3. Para- " "	. . .	λ 475 broad = $\lambda\lambda$ 491+460 in weaker acid.
4. CH ₃ -der. of (1) = benzeneazo- <i>p</i> -cresol (alkali)	. . .	λ 493 broad single.
5. SO ₃ K- " " = " <i>p</i> -phenolsulphonate	. . .	λ 455 " "
6. 2-4-6-tribromobenzeneazophenol (alkali)	. . .	$\lambda\lambda$ 430+384.
7. Benzeneazo- <i>o</i> -bromophenol	" . .	$\lambda\lambda$ 436+390.
8. 2-nitrobenzeneazophenol	" . .	$\lambda\lambda$ 487+440.
9. 4- " "	" . .	λ 490 broad single.
10. 4-nitrobenzeneazo- α -naphthol	" . .	λ 576 broad = $\lambda\lambda$ 602+552.
11. Foregoing in alcoholic alkali	. . .	λ 598 " = $\lambda\lambda$ 623+572.
12. No. 9 in " "	. . .	λ 502 " = $\lambda\lambda$ 540+490.
13. 4-sulphobenzeneazophenol (alkali)	. . .	λ 440 and ? 400.
14. 4-bromo- " " "	" . .	$\lambda\lambda$ 445+395.
15. 4-ethoxy- " " "	" . .	$\lambda\lambda$ 447+390.
16. 4-sulphobenzeneazo- <i>o</i> -cresol	" . .	λ 463 single.
17. 4- " " -m- " "	" . .	λ 475 "
18. Benzeneazoguaiacol	" . .	λ 460 broad single.
19. Benzenéazothymol	" . .	$\lambda\lambda$ 455+410.
20. " - α -naphthol	" . .	λ 496 broad single.
21. 4-sulphobenzeneazo- α -naphthol (alkali)	. . .	λ 513 " "
22. Benzeneazo-tetrahydro- α - " "	" . .	$\lambda\lambda$ 470+430.
23. " -catechol	" . .	$\lambda\lambda$ 480+430.
24. 4-diphenylazophenol	" . .	λ 451.
25. Diphenyltetrazo- <i>p</i> -phenolsulphonate (alkali)	. . .	λ 475 broad single.
26. 4-NO ₂ C ₆ H ₄ CH : NC ₆ H ₄ OH	" . .	λ 455 " "
27. 4-NO ₂ C ₆ H ₄ N : CHC ₆ H ₄ OH	" . .	λ about 410.
28. 4-NO ₂ C ₆ H ₄ CH : NC ₁₀ H ₆ OH α	" . .	$\lambda\lambda$ 560+505 in alcohol.
29. 4-NO ₂ C ₆ H ₄ N : CHC ₁₀ H ₆ OH α	" *	$\lambda\lambda$ 510 (+545 faint) in alcohol.
30. 4-diphenylazonaphthionic acid (in HCl)	. . .	λ 575 broad single.
31. Congo-red (in HCl)	. . .	λ 580 " "

From these we infer (1) that the ordinary substitutions have about the same small effect as in the dicyclic series: paranitro and naphthyl have the largest factors = 1.16 and 1.19 respectively; (2) the benzidine dyes are practically the same as the diphenyl dyes, *i.e.* only half the molecule acts,

* I have to thank Professor G. T. Morgan for this specimen (J.C.S., 1922, p. 5).

FUNGI OF THE STELLENBOSCH DISTRICT AND
IMMEDIATE VICINITY.

By Dr. P. A. VAN DER BIJL.

(From the Department of Phytopathology and Mycology, University of Stellenbosch.)

No separate list of the fungi occurring in the Stellenbosch district has so far been published.

For some years Miss A. V. Duthie has been collecting principally the Myxomycetes and the Higher Basidiomycetes occurring in the district, and I am indebted to her for kindly placing her collection at my disposal and for allowing me to embody it in the present paper.

The only way we can hope to learn the distribution of the South African fungi is to study closely those occurring over small areas, and to extend such work throughout the Union. More lasting benefit is to be derived from the close study of the fungi occurring over limited areas than collecting a few here, there, and everywhere.

In this connection Miss A. Pegler of Kentani rendered valuable service to the study of South African Mycology by giving close attention to the fungi occurring in her district.

In 1898 J. Medley Wood published a list of the fungi occurring in Natal. Incomplete as this list is, it is nevertheless of great assistance to anyone working on fungi in Natal.

In the present list the genera and species are listed alphabetically under the families to which they belong, and the host is also often stated. The Agariceae are omitted from this list. They will require a few seasons to work up satisfactorily, and will be dealt with later. In the case of specimens not collected by myself the name of the collector is always given. The list contains 98 genera, 148 identified species, and 20 fungi not specifically identified. As the study of the fungi of the district progresses the number will no doubt be considerably increased.

With the co-operation of students and friends it is hoped to work up the fungus flora of other districts as well, and to publish these from time to time.

MYXOMYCETES.

Plasmodiophorales.

Plasmodiophora brassicae, Wor., *Brassica oleracea*.

*Myxogastreales.**Ceratiomyxaceae.*

Ceratiomyxa fruticulosa, Macbr. Decayed wood. A. V. Duthie, June 1917.

Physaraceae.

Badhamia utricularis, Berk. Dead wood. A. V. Duthie, June 1917.

Diachaea leucopoda, Rost. Decayed leaves. A. V. Duthie, Aug. 1916.

Diderma effusum, Morg. A. V. Duthie.

Fuligo septica, Gmelin. Decayed wood.

Leocarpus fragilis, Rost. Dead needles of *Pinus*. A. V. Duthie, Aug. 1916.

Physarum auriscalpum, Cke. Dead needles of *Pinus*. A. V. Duthie, Aug. 1916.

Physarum pusillum, Lister. Dead stem, *Solanaceae*. A. V. Duthie.

Physarum sinuosum, Weinm. A. V. Duthie.

Physarum vernum, Somm. A. V. Duthie.

Didymiaceae.

Didymium difforme, Duby. A. V. Duthie.

Didymium nigripes, var. *xanthopus*, Lister. A. V. Duthie.

Stemonitaceae.

Comatricha nigra (Pers.), Schroet. A. V. Duthie.

Lamproderma scintillans, Morgan. On moss. A. V. Duthie.

Stemonitis splendens, Rost. Dead wood. A. V. Duthie.

Stemonitis splendens, Rost., var. *Webberi*, Lister. A. V. Duthie.

Heterodermaceae.

Cribraria argillacea, Pers. Decayed stump, *Pinus*. A. V. Duthie, May 1917.

Dictydium cancellatum, Macbr. A. V. Duthie.

Reticulariaceae.

Dictydialaethalium plumbeum, Rost. Dead wood. A. V. Duthie.

Reticularia lycoperdon, Bull. Dead wood. A. V. Duthie.

Lycogalaceae.

Lycogala epidendrum, Fr. Dead wood. A. V. Duthie.

Lycogala flavo-fuscum, Rost. A. V. Duthie.

Arctyriaceae.

- Arctyria cinerea* (Bull.), Pers., *Forma digitata*. Dead wood. A. V. Duthie.
Arctyria denudata, Sheldon. Dead wood. A. V. Duthie.
Arctyria nutans, Grév. Dead wood. A. V. Duthie.
Arctyria Oerstedtii, Rost. Dead wood. A. V. Duthie.

SCHIZOMYCETES.

- Actinomyces scabies* (Thax.), Guss., *Solanum tuberosum*.
Bacterium nectarophilum, Doidge, *Pirus communis*.
Bacterium tumefaciens, Sm., *Pirus malus*.
Pseudomonas pruni, Sm., *Prunus persica*, Nov. 1921; *Prunus domestica* (Prunes), Jan. 1922.

PHYCOMYCETES.

Albuginaceae.

- Albugo candida*, Lér., *Cochlearia Armourica*, Dec. 1921; *Raphanus raphanistrum*.

Entomophthoraceae.

- Empusa Grylli* (Fres.), Nowakowski.
Empusa muscae, F. Cohn.

ASCOMYCETES.

Eroascaceae.

- Taphrina aurea*, Fr., *Populus pyramidalis*, Dec. 1921.
Taphrina deformans (Fcl.), Tul., *Prunus persica* (Peach and nectarines).

Helvellaceae.

- Morchella conica*, Pers. On ground. A. V. Duthie.

Pezizaceae.

- Lachnea hemisphaerica* (Wigg.), Gill. A. V. Duthie.
Lachnea sp. A. V. Duthie.
Peziza spp. Two large species and several smaller ones. A. V. Duthie.

Mollisiaceae.

- Aspergillus niger*, Bref., *Allium cepa*. Nov. 1921.

Erysiphaceae.

- The fungi in their family were only found in their conidial fructifications. Their identification was hence based on the hosts on which they occurred.
Erysiphe cichoracearum, D. C., *Cucumis pepo*., *Nicotiana tabacum*.
Erysiphe polygoni, D. C., *Pisum sativum*. Nov. 1921.

Podosphaera leucotricha (Ell. and Ev.), Salmon *Pirus malus*. Nov. 1921.

Sphaerotheca pannosa (Wallr.), Lév., Rosa sp. Nov. 1921.

Uncinula necator (Schwein.), Burr, *Vitis vinifera*.

Hypocreaceae.

Claviceps paspali, S. & H., *Paspalum*. Feb. 1922.

Claviceps sp., *Pennisetum macruorum*.

Dothidiaceae.

Phyllachora cynodontis (Sacc.), Niess., *Cynodon dactylon*. Feb. 1922.

Phyllachora melianthi (Thuem.), Sacc., *Melianthus major*. Oct. 1922.

Phyllachora sp., *Pennisetum macruorum*. March 1922.

Coryneliaceae.

Corynelia uberata, Ach., *Podocarpus*. Oct. 1921.

Mycosphaerellaceae.

Mycosphaerella fragariae (Tul.), Linn., *Fragaria vesca*.

Pleosporaceae.

Venturia inaequalis (Cke.), Aderh. (*Fusicladium* stage), *Pirus malus*.

Venturia pirina, Aderh. (*Fusicladium* stage), *Pirus communis*.

Melanconidaceae.

Calospora arausiaca (Fab.), Sacc., *Quercus* sp.

Xylariaceae.

Hypoxylon sp. Old wood. A. V. Duthie.

Xylaria sp. Old wood. A. V. Duthie.

BASIDIOMYCETES.

Ustilaginaceae.

Ustilago avenae (Pers.), Jens., *Avena sativa*. Nov. 1921.

Ustilago bromivora (Tul.), F. v. M., *Bromus unioloides*. Oct. 1921.

Ustilago hordei (Pers.), K. & S., *Hordeum vulgare*. Sept. 1921.

Ustilago maydis (D. C.), Tul., *Zea Mays*.

Ustilago nuda (Jens.), K. & S., *Hordeum vulgare*. Oct. 1921.

Tilletiaceae.

Tilletia laevis, Ruhn., *Triticum vulgare*.

Urocystis tritici (Bjerk.), Wint., *Triticum vulgare*. Oct. 1921.

Melampsoraceae.

Melampsora tremulae, Tul., *Populus* sp. Sept. 1921.

Pucciniaceae.

Aecidium resinicolum, var. *tumefaciens*, Wint., *Raphnia angulata*.

Oct. 1911.

Phragmidium subcorticum, Wint., *Rosa* sp. Nov. 1921.

Phragmidium violaceum (Schultz), Wint., *Rubus Vitifolius*.

Puccinia chrysanthemi, Roze., *Chrysanthemum* sp.

Puccinia graminis, Pers., *Avena sativa*, *Hordeum sativum*, *Triticum vulgare*.

Puccinia granularis, K. & Cke., *Pelargonium* sp.

Puccinia hypochaeridis, Oud., *Hypochaeris radicata*. Oct. 1921.

Puccinia malvacearum, Mont., *Malva parviflora*. Oct. 1921. *Mathiola* sp.

Puccinia maydis, Bereng., *Zea Mays*. Feb. 1922.

Puccinia phragmites (Schum.), Koern., *Phragmites communis*.

Uredo Fici, Cast., *Ficus* sp.

Uromyces betae (Pers.), Kuhn., *Beta vulgaris* sp. 1921.

Uromyces cyperi, P. Henn., *Cyperus* sp. Oct. 1921.

Uromyces fabae (Pers.), de B., *Vicia Faba*. Oct. 1921.

Uromyces romuleae, n. sp., P. v. d. B. (MSS. name), *Romulea rosea*.

Uromyces striatus, Schroet., *Medicago sativa*.

Tranzschelia punctata (Pers.), Arth., *Amygdalus communis*; *Prunus armeniaca*; *Prunus domestica* (Prunes); *Prunus persica*.

Tremellaceae.

Exidia purpureo-cinerea, Kalch. Dead branch, *Quercus*, Sept. 1921.

Old log, Oct. 1921.

Tremella sp. A. V. Duthie.

Tremella microspora, Lloyd. A. V. Duthie.

Dacromycetaceae.

Dacromyces deliquescens (Bull.), Duby. Old log. A. V. Duthie.

Hormomyces aurantiacus, Bon. Logs, *Quercus*. A. V. Duthie.

Thelephoraceae.

Stereum hirsutum (Willd.), Pers. Common saprophyte on logs of *Quercus* and other plants.

Stereum purpureum, Pers. Old logs *Quercus*. Aug. 1922.

Stereum vellereum, Berk. Old logs *Quercus*.

Thelephora intybacea (Pers.), Fr. In plantations, *Pinus*.

Thelephora penicillata, Lloyd. A. V. Duthie.

Polyporaceae.

Lenzites betulina, Linn. Stump, *Quercus*. Aug. 1921.

Lenzites Quineensis, Fr. (form of above). Old logs. Oct. 1921.

Merulius lachrymans, Facq. A. V. Duthie.

- Trametes protea*, Berk. Stump and logs of *Pinus*, *Populus*, and *Quercus*.
Trametes trabea, Otth. Logs of *Pinus*.
Polyporus adustus, Willd. Stumps *Quercus*. Aug. 1921.
Polyporus conchatus, Lloyd. Stump *Populus*.
Polyporus occidentalis, Klotz. Old logs. A. V. Duthie.
Polyporus ochraceus, Pers. Old logs. A. V. Duthie.
Polyporus rusticus, Lloyd. Log *Pinus*.
Polyporus sanguineus (Linn.), Fr. Old logs. A. V. Duthie.
Polyporus sulphureus (Bull.), Fr. Wound parasite of *Quercus*. Burned stump of *Eucalyptus*.
Polyporus versicolor (Linn.), Fr. Wound parasite of *Prunus persica*.
Common saprophyte on various old logs.
Polyporus zonatus, Fr. A. V. Duthie.

Boletaceae.

- Boletus edulis*, Bull. On ground.
Boletus, n. sp. (Herb. No. 508). On ground.

Agaricaceae.

- Amanita muscaria* (Linn.), Pers. On ground. A. V. Duthie.
Amanita phalloides (Fr.), Quél. On ground. A. V. Duthie.
Lentinus Lepideus, Fr. Stump of *Pinus*.
Schizophyllum commune Fr. Wound parasite on *Prunus persica* and
Acacia saligna. Common saprophyte on logs of various trees.

Phallaceae.

- Anthurus Mac Owani*, Marl. On ground. A. V. Duthie.
Phallus sp. On ground. A. V. Duthie.

Hymenogastraceae.

- Rhizopogon luteolus*, Fr. On ground. A. V. Duthie.
Rhizopogon rubescens, Tul. On ground.
Rhizopogon sp. On ground. A. V. Duthie.

Hysterangiaceae.

- Protuberia africana*, Lloyd. On ground. A. V. Duthie.

Lycoperdaceae.

- Calvatia lilacina*, Berk. On ground. A. V. Duthie.
Catastoma magnum. On ground. A. V. Duthie.
Geaster plicatilis, Berk. On ground.
Lycoperdon pratense, Pers. On ground. A. V. Duthie.

Nidulariaceae.

- Cyathus vernicosus* (Bull.), D. C. On ground. A. V. Duthie.

Podazaceae.

Podaxon carcinomalis, Fr. On termite nest. A. V. Duthie.

Sclerodermataceae.

Arachnion album, Schw. On ground. A. V. Duthie.

Arachnion scleroderma, Lloyd. On ground. A. V. Duthie.

Polysaccum crassipes, Fr. On ground under Eucalyptus trees.

Scleroderma cepa, Pers. On ground. A. V. Duthie.

Scleroderma laeve, Lév. On ground. A. V. Duthie.

Scleroderma flavidum, Ellis. On ground. A. V. Duthie.

Scleroderma tenerum, Berk. On ground. A. V. Duthie.

Tulostomataceae.

Tulostoma cyclophorum, Lloyd. On ground. A. V. Duthie.

Tulostoma sp. (a small plant). On ground. A. V. Duthie.

DEUTEROMYCETES.

Sphaerioidaceae.

Actinonema rosae (Lib.), Fr., *Rosa* sp. Nov. 1921.

Ascochyta pisi, Lib., *Pisum sativum*. Nov. 1921.

Phyllosticta richardiae, Hals., *Zantedaschia aethiopica*. Oct. 1921

Phyllosticta violae, Desm., *Viola odorata*. Nov. 1921.

Septoria graminum, Desm., *Triticum vulgare*. Sept. 1921.

Septoria lycopersica, Speg., *Solanum lycopersicum*. Feb. 1922.

Septoria pelargonii, Syd., *Pelargonium* sp. C. K. Brain.

Septoria pisi, Went., *Pisum sativum*.

Septoria rubi, West., *Rubus vitifolius*. M. M. Radloff. Oct. 1921.

Septoria sp., *Silene gallica*.

Sphaeropsis malorum, Peck, *Cydonia vulgaris*; *Pirus malus*.

Melanconiaceae.

Gloeosporium ampelophagum, Sacc., *Vitis vinifera*. Dec. 1921.

Pestalozia sp., *Pirus malus*. Oct. 1921.

Septogloeum arachidis, Rac., *Arachis hypogaea*. Feb. 1922.

Septogloeum mori, Lév., *Morus* sp. March 1922.

Moniliaceae.

Botrytis cinerea, Pers., *Vitis vinifera*. March 1921.

Botrytis sp., *Lathyrus odorata*.

Oidiopsis taurica, Lév., *Tropaeolum major*. Feb. 1922.

Oidium sp., *Euphorbia* sp. Nov. 1921.

Oidium sp., *Quercus* sp. Nov. 1921.

Dematiaceae.

- Alternaria solani* (E. & M.), Jones & Grout, *Solanum tuberosum*, Nov.
1921. *Solanum lycopersici*, Feb. 1922.
Cercospora protearum, Cke., *Leucospermum conocarpum*.
Cladosporium zeae, Peck., *Zea Mays*. Feb. 1922.
Coniothecium macowanii, Sacc., *Protea grandiflora*. June 1913.
Macrosporium cladosporioides, Desm., *Beta vulgaris*. Feb. 1922.
Macrosporium iridis, C. & E., *Iris* sp. Feb. 1922.
Macrosporium maydis, C. & E., *Zea Mays*. Feb. 1922.
Macrosporium sp., Tree tomato. Dec. 1921.
Macrosporium sp., *Eriobotryon japonica*. Feb. 1922.
Macrosporium sp., *Populus* sp. March 1922.

Mucedinaceae.

- Rhinotrichum rubiginosum*, Fr. A. V. Duthie.

Stilbaceae.

- Isaria* sp., *Goniapterus scutellatus*. C. K. Brain.

MYCELIUM STERILE.

- Rhizoectonia*, *Solanum tuberosum*.

OBSERVATIONS ON THE PROTECTIVE ACTION
OF NORMAL SERUM IN EXPERIMENTAL INFECTION WITH
BACILLUS DIPHThERIAE.

By T. J. MACKIE, M.D., Ch.B., D.P.H.

(From the Department of Bacteriology, University of Cape Town.)

In carrying out test inoculations in guinea-pigs with *B. diphtheriae* and diphtheroid bacilli for purposes of identification, where control animals were injected with the particular strain plus a certain amount of diphtheria antitoxin, it was noted that these animals were protected against lethal doses of *B. diphtheriae* by normal horse serum as well as by the specific immune serum. Though this observation did not involve any quantitative comparisons between the effect of the normal and the immune serum, the fact that normal horse serum should act protectively in the same way as the serum of a specifically immunised animal seemed of considerable importance, and suggested the further investigation of the phenomenon. This normal-serum effect is also of general interest in relation to "non-specific therapy," where alien protein (*e.g.* animal serum, bacterial protein, etc.), injected parenterally, is found to exert a favourable influence on the course of various infections in a non-specific manner.

With a view, therefore, to analysing the effect, a series of experiments were carried out which fully established the original observation, and yielded further information of some theoretic and practical interest.

The protective and curative action of normal horse serum in *B. diphtheriae* infection and intoxication has also been studied by other workers.

Kolle and Schlossberger concluded that in guinea-pigs infected with *B. diphtheriae* normal horse serum had a limited curative effect, which was in no way comparable with that of an antitoxic serum, and in the case of animals injected with diphtheria toxin had a certain "delaying" action but was not definitely curative. They stated that the effect was "non-specific, resistance-increasing, stimulating," but did not offer any further explanation of their results. Kraus and Sordelli claimed that normal horse serum contains antitoxin to diphtheria toxin, and in virtue of this exerts a "preventive" effect against *B. diphtheriae* and its toxin. Cowie and Greenthal showed that 1 c.c. of normal horse serum injected subcutaneously

and intravenously in guinea-pigs simultaneously with diphtheria toxin always protects against 1 M.L.D., and may neutralise even 8 M.L.D.; they showed that the activity of the serum depends on the proteins and not on the alcohol-soluble fraction. They regarded the protective power as not entirely due to a natural diphtheria antitoxin.

In the writer's original experiments guinea-pigs of approximately 350 grms. weight were injected subcutaneously with 2 c.c. of a 2-days bouillon culture of virulent strains of *B. diphtheriae*, and at the same time 5-10 c.c. of normal horse serum were injected subcutaneously at a different site from that of inoculation; these animals survived, while animals of similar weight, injected with the same amount of the same cultures, died within 24 to 48 hours, showing at autopsy the characteristic effects of *B. diphtheriae* inoculations. Various strains and different specimens of normal horse serum gave the same results.

For the detailed investigation, particular strains of *B. diphtheriae* isolated from typical cases of throat diphtheria were used.

DEGREE OF PROTECTIVE ACTION OF NORMAL HORSE SERUM.

In order to ascertain quantitatively the degree of protection conferred by normal serum, guinea-pigs of approximately equal weight were injected subcutaneously with a fixed quantity of a *B. diphtheriae* bouillon culture, and at the same time with varying amounts of horse serum; the minimum lethal dose of the culture was also estimated in parallel experiment (Table I).

Thus 2 c.c. of serum protected against at least 12 lethal doses of the culture (i.e. 1 c.c. serum against 6 M.L.D.).

TABLE I.

Guinea-pigs approximately 400 grms. weight injected subcutaneously in flank with 3 c.c. of a 2-days bouillon culture of *B. diphtheriae*, "strain 3"; varying amounts of normal horse serum injected subcutaneously in back.

1.	<i>B. diphtheriae</i> + 6 c.c.	serum	.	.	survived.
2.	" + 5 c.c.	"	.	.	"
3.	" + 4 c.c.	"	.	.	"
4.	" + 3 c.c.	"	.	.	"
5.	" + 2 c.c.	"	.	.	"
6.	" + 1 c.c.	"	.	.	died 6th day.
7.	" + 0.5 c.c.	"	.	.	" 4th "
8.	" + 0.25 c.c.	"	.	.	" 3rd "
9.	" + 0.1 c.c.	"	.	.	" 4th "
10.	" no serum	"	.	.	" 2nd "

MINIMUM LETHAL DOSE ESTIMATION.

Guinea-pigs approximately 400 grms. weight: same culture injected subcutaneously.

1.	B. diphtheriae bouillon culture,	1.5 c.c.	.	.	died 2nd day.
2.	"	"	"	1.0 c.c.	" 2nd "
3.	"	"	"	0.5 c.c.	" 4th "
4.	"	"	"	0.25 c.c.	" 7th "
5.	"	"	"	0.1 c.c.	survived.
6.	"	"	"	0.05 c.c.	"

PROPHYLACTIC AS OPPOSED TO CURATIVE EFFECT.

It was found that normal serum, though protective or prophylactic, was not curative; thus, to elicit the antagonistic effect, the serum had to be injected without delay after the introduction of the infecting organisms; if an interval of two hours or longer was allowed to elapse before the serum was injected, even when five times the protective dose was used, the animals died (Table II).

THERMOSTABILITY OF THE ACTIVE SUBSTANCE IN THE SERUM.

In thermostability the active principle of the serum corresponds generally to antitoxin and other antibodies. Horse serum heated for one hour at 57° C. was still protective, but was inactivated by exposure at 70° C. for half an hour and at higher temperatures (Table III). The thermostability at 57° C. excluded the possibility of the active substance being of complement nature.

TABLE II.

Guinea-pigs approximately 400 grms. weight injected subcutaneously in flank with 3 c.c. 2-days bouillon culture of *B. diphtheriae*, "strain 3"; 10 c.c. normal horse serum injected subcutaneously in back at varying intervals after injection of the culture.

1.	B. diphtheriae + serum,	simultaneously	.	.	survived.
2.	"	+ "	after 2 hours	.	died 3rd day.
3.	"	+ "	" 4 "	.	" 2nd "
4.	"	+ "	" 24 "	.	" 2nd "
5.	"	no serum.	.	.	" 2nd "

TABLE III.

Guinea-pigs approximately 450 grms. weight injected subcutaneously in flank with 3 c.c. of a 2-days bouillon culture of *B. diphtheriae*,

"strain 2"; normal horse serum injected subcutaneously in back at same time.

1.	B. diphtheriae + 10 c.c. unheated serum	survived.
2.	" no serum	died 2nd day.
3.	" + 10 c.c. serum, 57° C., 1 hr.	survived.
*4.	" + 50 c.c. of a serum dilution, 1 part in 5 of normal saline, heated at 70° C., $\frac{1}{2}$ hr.	died 2nd day.
*5.	" + 60 c.c. of a serum dilution, 1 part in 5 of normal saline, heated at 90° C., $\frac{1}{2}$ hr.	died 2nd day.
*6.	" + 50 c.c. of a serum dilution, 1 part in 5 of normal saline, heated at 100° C. for 5 minutes	died in 24 hours, showing more marked lesions than other animals; marked haemorrhagic in- flammatory oedema at site of inoculation, with marked haemorrhages in suprenals, lungs, and intestinal wall.

EXPERIMENTS WITH RABBITS.

Using rabbits as the test animal, horse serum was found to exert the same protective action against B. diphtheriae as in the case of guinea-pigs; the particular effect was not therefore limited to B. diphtheriae infection in one species of animal only. Table IV exemplifies one of these experiments.

TABLE IV.

Rabbits of equal weight injected subcutaneously with 4 c.c. of a 3-days bouillon culture of B. diphtheriae, "strain 3."

1. + 20 c.c. normal horse serum injected
subcutaneously at different site . . . survived.
2. No serum died 3rd day.

* The serum was diluted to prevent coagulation on heating.

PROTECTIVE ACTION OF THE SERUM OF DIFFERENT ANIMALS.

The serum from various animal species (ox, sheep, man, rabbit, cat) was found to confer the same protection as horse serum; in the experiments of other workers on this subject the phenomenon has been studied from the point of view apparently of its being related to horse serum only; the effect is, however, not characteristic of the serum of only one species of animal (Table V).

The question then arose as to whether the serum of one guinea-pig injected parenterally into another guinea-pig would protect the latter against *B. diphtheriae* infection. To ascertain this a number of experiments were carried out, but with variable results: in some cases complete protection was obtained; in others, while the infected animals succumbed to the dose given, there was a distinct delaying of the lethal effect (Table VI). Thus it was apparent that though protection by normal serum from an alien species was the general rule, the serum of the same species was not without a similar effect.

TABLE V.

Guinea-pigs approximately 450 grms. weight injected subcutaneously in flank with 3 c.c. of a 2-days bouillon culture of *B. diphtheriae*, "strain 2"; serum of various animals injected subcutaneously in back at same time.

1.	<i>B. diphtheriae</i> + 10 c.c. ox serum	.	.	survived.
2.	" + 10 c.c. sheep's serum	.	.	"
3.	" + 8 c.c. human serum	.	.	"
4.	" + 10 c.c. cat's serum	.	.	"
5.	" + 6 c.c. rabbit's serum	.	.	"
6.	" + 3 c.c. " " (55° C.)	.	.	"
7.	" + 10 c.c. horse serum	.	.	"
8.	" no serum.	.	.	died 2nd day.

TABLE VI.

Guinea-pigs approximately 400 grms. weight injected subcutaneously with 3 c.c. 2-days bouillon culture of *B. diphtheriae*; serum from other guinea-pigs injected subcutaneously at a different site.

1.	(a) <i>B. diphtheriae</i> , "strain 2" + 6 c.c. serum	.	.	died 6th day.
	(b) control (no serum injected)	.	.	" 2nd "
2.	(a) <i>B. diphtheriae</i> , "strain 2" + 8 c.c. serum (55° C.)	.	.	survived.
	(b) control	.	.	died 2nd day.

A powerful toxin was prepared from *B. diphtheriae*, "strain 3." It was found that 10 c.c. of horse serum was protective against 10 M.L.D. of the

toxin (1 c.c. against 1 M.L.D.), whereas 1.5 c.c. of diphtheria antitoxin, representing 1000 immunity units, protected against 10,000 M.L.D. The minimum lethal dose was estimated in parallel experiments along with the protective tests (Table VII).

A similar series of experiments were carried out in which the pooled serum of three guinea-pigs was substituted for horse serum (Table VIII).

The parenteral injection of 10 c.c. of guinea-pig's serum had apparently no protective action in guinea-pigs against B. diphtheria toxin.

TABLE VII.

Guinea-pigs 250 grms. weight injected subcutaneously in flank with varying doses of diphtheria toxin; at the same time injected subcutaneously in back with 10 c.c. normal horse serum.

1.	Toxin 0.1	c.c. + 10 c.c. serum	.	.	died 2nd day.
2.	" 0.05	c.c. + "	"	.	" 2nd "
3.	" 0.01	c.c. + "	"	.	" 7th "
4.	" 0.005	c.c. + "	"	.	" 12th "
5.	" 0.001	c.c. + "	"	.	survived.
6.	" 0.0005	c.c. + "	"	.	"
7.	" 1	c.c. + 1000 immunity units			
		diphtheria antitoxin			"

M.L.D. Estimation.

1.	Toxin 0.1	c.c.	.	.	died 2nd day.
2.	" 0.01	c.c.	.	.	" 2nd "
3.	" 0.001	c.c.	.	.	" 2nd "
4.	" 0.0005	c.c.	.	.	" 2nd "
5.	" 0.0001	c.c.	.	.	" 3rd "
6.	" 0.00005	c.c.	.	.	survived.
7.	" 0.00001	c.c.	.	.	"

M.L.D.—0.0001 c.c.

NOTE.—The small doses of toxin 0.05 c.c.—0.00001 c.c. were measured by preparing decimal dilutions of the toxin 1 : 10, 1 : 100, 1 : 1000, 1 : 10,000, 1 : 100,000 and injecting the appropriate quantities of these dilutions.

TABLE VIII.

Guinea-pigs 250 grms. weight injected subcutaneously in flank with varying doses of diphtheria toxin; at the same time 10 c.c. of guinea-pig's serum (from three animals, pooled) injected subcutaneously in back.

1.	Toxin 0-001	c.c.+10 c.c. serum	.	.	died 2nd day
2.	"	0-0001 c.c.+	"	.	" 2nd "
3.	"	0-00005 c.c.+	"	.	survived.
4.	"	0-00001 c.c.+	"	.	"

Lethal Dose Estimation.

1.	Toxin 0-001	c.c.	.	.	died 2nd day.
2.	"	0-0001 c.c.	.	.	" 2nd "
3.	"	0-00005 c.c.	.	.	survived.
4.	"	0-00001 c.c.	.	.	"

THE OCCURRENCE OF LOCAL LESIONS IN ANIMALS SURVIVING AFTER
PROTECTION BY SERUM.

An interesting feature of these experiments was the occurrence of a marked local lesion in animals surviving after protection by normal serum against *B. diphtheriae* or its toxin.

After two to three days a well-marked subcutaneous indurated swelling with surrounding inflammatory oedema developed at the site of injection of the organisms or toxin; the overlying skin then became necrotic and sloughed, leaving a punched-out ulcer with a grey sloughing base; the lesion attained its full development in eight to ten days, and then slowly healed; in one instance the lesion involved the deeper tissues, and led to perforation of the whole abdominal wall.

It was found that diphtheria antitoxin prevented the occurrence of the local lesion as well as the general effects.

This type of lesion occurred in rabbits protected by serum as well as in the case of guinea-pigs.

In the infection experiments no diphtheria bacilli could be detected in the ulcers after sloughing of the skin, either by microscopic examination or culture. On the other hand, in experiments where the injection of guinea-pig serum delayed the lethal effect of *B. diphtheriae* for several days (*e.g.* eight days, nineteen days, *v.* Table VI), and similar sloughing ulcers developed at the site of inoculation, *B. diphtheriae* were present in the lesion.

Thus the parenteral injection of normal serum, though protecting against the toxic result of infection with *B. diphtheriae*, had no influence on its local toxic action. It was apparent also that *B. diphtheriae* did not persist in the tissues of animals fully protected by serum.

In unprotected animals the local lesion of the type described is not commonly met with, as animals infected with a sufficient dose die within a few days; for the full development of the local effect a period of eight to

ten days is required, and it was apparent that the occurrence of this particular lesion in protected animals was simply dependent on the survival of the animal. In rabbits, which are less susceptible to experimental *B. diphtheriae* infection and resist larger doses than guinea-pigs, it has been noted that sub-lethal doses may produce similar marked local lesions apart from any serum protection.

DISCUSSION.

These observations represent a further contribution to the study of non-specific immunisation by parenteral injection of normal serum.

While it is possible that in the case of horse serum a natural antitoxin may contribute to the protection noted, and it is of importance that the active substance in the serum corresponds to antibodies in thermostability, the action of the serum in bringing about some other antagonistic effect must be considered. This effect apparently does not depend on the transference of bactericidal complement or a natural bactericidal antibody; the serum is protective against infection apart from intoxication; thus the organisms are absent from the local lesion. It might be claimed, however, that the antitoxic factor contributes to the elimination of the bacteria by rendering them more susceptible to phagocytosis through neutralisation of their toxin. It is to be noted also that normal serum is not antitoxic as regards the local toxic effects, whereas diphtheria antitoxin protects animals against local as well as general effects. The fact that the parenteral injection of the serum of one guinea-pig into another exerts a "delaying" effect in diphtheria infections and even complete protection, though this species has little natural immunity to *B. diphtheriae* and no natural antitoxin can be demonstrated in the serum, clearly indicates that some mechanism other than that of a natural antitoxin or other antistubstance transferred with the serum plays the important part in increasing the resistance of the animal.

These experiments are therefore of interest in their bearing on the general question of "non-specific immunity," and provide a further illustration of how the resistance of the tissues to a particular organism may be enhanced by the parenteral injection of normal serum. The results, however, clearly exclude the possibility that normal horse serum could be as effective a therapeutic agent as a potent diphtheria antitoxin.

CONCLUSIONS.

1. In guinea-pigs experimentally infected with *B. diphtheriae*, normal serum (horse, ox, sheep, cat, human), injected subcutaneously at the same time as the inoculation, exerts a definite protective action.

2. Two c.c. of normal horse serum may protect in this way against 12 M.L.D. of a *B. diphtheriae* culture.

3. No protection occurs if the serum injection is delayed for two hours after the inoculation.

4. The activity of the serum persists at 57° C., but is lost at 70° C. and higher temperatures.

5. The serum of one guinea-pig injected subcutaneously into another is either protective to the latter experimentally infected with *B. diphtheriae*, or at least exerts a definite delaying effect on the course of the infection.

6. Normal horse serum is also similarly protective in guinea-pigs injected with diphtheria toxin; 10 c.c. of serum may protect against 10 M.L.D.

7. The serum of one guinea-pig is not protective in the case of another injected with diphtheria toxin.

8. In the case of animals surviving after protection by normal serum, a marked local lesion develops at the site of inoculation.

REFERENCES.

KOLLE and SCHLOSSBERGER.—*Med. Klinik*, 1919 (also quoted by Kraus and Sordelli).

KRAUS and SORDELLI.—*Zeit. f. Immunitäts.*, Teil i, Orig. 31, 2, 1921, 107.

COWIE and GREENTHAL.—*Journ. Med. Research*, 1921, 42, 261.

ON SOME UPPER BEAUFORT THERAPSIDA.

By S. H. HAUGHTON, B.A., D.Sc.

(Published by permission of the Hon. the Minister for Mines and Industries.)

(With Plate XIII and two Text-figures.)

CYNIDIOGNATHUS LONGICEPS, gen. et sp. nov.

The specimen which forms the type of this new genus was collected on the farm Vaalbank, Albert District, at the foot of the northern slope of the Dreunberg during the course of the geological survey of the area carried out in 1921. It consists of an almost perfect skull with part of the lower jaw, and some fragmentary limb-bones, but the skull only will be described here.

The principal measurements are as follows :—

Maximum length	375 mm.
Dorsal length in mid-line	330 mm.
Maximum width	240 mm.
Width at canines	80 mm.
Interorbital width	51 mm.
Snout to front of orbit	180 mm.
Orbital diameter	50 mm.
Snout to back of pterygoid flange	200 mm.
Maximum height	95 mm.

Premaxilla.—The two bones are separated by well-marked suture. Each bone carries 4 incisors, but at the alveolar edge the facial portion is fairly short. It extends backwards in its lower portion to form the lower border of the external nares, but does not meet the nasal behind the nostril. Above the nostril each premaxilla sends backwards a narrow tapering process to the level of the back of the outer nares, the two processes lying between the front parts of the nasals.

The palatal portion of the premaxilla is partly seen, although the ventral surface has not been fully displayed. On the ventral surface, however, the

premaxilla passes backwards to the level of the back of the canine, appearing in its posterior part as a narrow splint of bone lying medial to the maxilla. The dorsal surface has been almost completely developed. Anteriorly the bone forms the floor and outer side of the nasal opening—no ossified inter-nasal septum being present. Near the front of the nasal floor on each side there is a rounded foramen, and just anterior to this the septomaxilla lies on the premaxilla. Behind the septomaxilla the lateral portion of the premaxilla is a thin inclined plate of bone lying on the maxilla and passing back to the level of the back of the canine. Medial to this plate there is a deep channel which is flanked medially by an upstanding process, somewhat swollen above, which extends from the level of the last incisor to the level of the front of the canine. This palatine process forms the inner wall of the premaxilla and is separated from its neighbour by a deep narrow channel, which is partly divided by a longitudinal thin bony plate not reaching down to the secondary palate. This palatine process of the premaxilla does not seem to be separate from the main body of the bone. The bone is somewhat cracked, and the cracks are filled with red iron oxide; but the cracks are so unsymmetrical, and no one of them can be matched by a counterpart on the other side, that none can be considered as a suture dividing off the premaxilla from a prevomer.

Broom has mentioned and figured the occurrence of such processes in *Lycorchampsia ferox* and Watson in *Gomphognathus polyphagus*, but no adequate description has been given of either.

Septomaxilla.—This bone is only preserved in the right nostril. It lies on the floor and against the lateral portion of the premaxilla and is almost completely separated by that bone from the maxilla, only meeting the latter at its upper corner. The front lower half of the bone is a very thin lamina, concave from above (called the pars horizontalis of the os narialis by Wegner, 1922). Half-way up it thickens considerably and sends inwards a fairly thin turbinal process (processus intrafenestralis of Wegner) which almost reaches the mid-line of the skull. The turbinal process lies wholly in front of the palatine process of the premaxilla. On the floor of the nostril there is a foramen between the front of the septomaxilla and the narial portion of the premaxilla. The septomaxillary foramen is very small.

Maxilla.—The maxilla carries 1 large canine and 10 molars. The molar series occupies a length of 103 mm. Only the sockets of the molars are preserved. These are longer than wide, and begin almost directly behind the canine. The last tooth is very small.

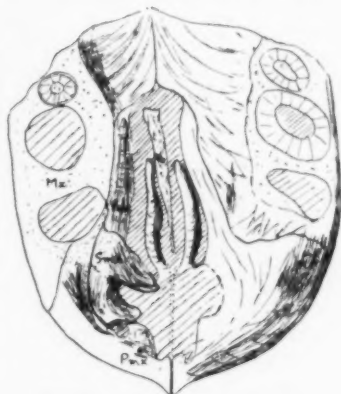
Lachrymal.—This bone has contact with the prefrontal, nasal, maxilla, and jugal. In front of the orbit it is excavate as in many Gorgonopsids and is bounded behind by a pronounced ridge which forms here the antorbital border. At the bottom of the excavated portion is the lachrymal foramen

which forms the entrance to a short duct running through the bone whose posterior end opens into the orbit.

The other bones of the face and of the top of the skull are very similar to those of *Cynognathus platyceps*, and their shapes and relationships are adequately displayed in the figure.

"Vomer."—In section anterior to the orbit the vomer is broad, thin, slightly concave downwards, with a ventral median keel and a dorsal median groove flanked by thin upstanding walls. When traced forward in longitudinal section the horizontal plate gradually disappears, the vertical plate becomes higher and its ventral portion swells, so that at the anterior end, between the palatine processes of the premaxillæ, the median plate is sharp-pointed above and rounded below. At the anterior end the bone-mass is certainly single; along its length there may possibly be a suture separating an upper portion from a lower; but the median septum, except in its lower swollen portion, is very thin and much cracked, so that it is not possible to be absolutely certain of the presence of a suture. If a suture is present, then the bone between the premaxillæ is the vomer, and the bone which roofs the pharynx is the parasphenoid; or the former is the fused prevomers and the latter the vomer. It is certain that the bone which roofs the pharynx forms the upper part of the median septum at least; and that the condition is different from that figured by Broom in *Diademodon*, in that no mesethmoid forms the upper part of the septum. On the other hand, if the bone is single, the changes which take place in it when traced forward from the pharynx are the gradual loss of the horizontal septa, the thickening of the ventral part of the vertical plate, and the complete or almost complete fusion of the walls of the dorsal groove.

Posterior to the line of fracture in front of the orbits, the "vomer" becomes more arched with a ventral median keel and passes rapidly downwards and backwards, forming the front part of the groove in the palate; the hinder portion of this groove is formed by the pterygoids. Broom and Watson have both figured this region in *Diademodon*, and have shown the vomer as forming the whole of this vaulted area of the palate, and Watson



Cynidiognathus longiceps.—Htn.
Irregular section across snout. Dorsal view. Left septomaxilla not preserved.

has further figured a large vomer in this position in some Gorgonopsia. I have elsewhere expressed my inability to see a vomer separating the pterygoids in Gorgonopsian skulls which I have examined, and the evidence afforded by this Cynodont skull seems to re-open the whole question of the identity of the bone which forms the median septum of the anterior part of the skull and the roof of the front part of the pharynx.

Is it the anterior prolongation of the parasphenoid? or is it the fused prevomers of the Therocephalia? Its position in front of, and slightly flanked by, the pterygoids, and between the palatines, would seem to homologise it with the prevomers; and until further evidence of its actual connection with the parasphenoid is obtained, it would seem best to consider it as the fused prevomers.

Basicranium.—The basicranial region is similar to that of *Cynognathus* in general plan, but there are significant points of difference. The pterygoid is large, the vomer extends back at least to the front of the median bar; and posteriorly the pterygoids stop some distance in advance of the triangular basisphenoid plate and are separated from each other by an anterior prolongation of the basisphenoid along the median bar. Laterally the posterior portion of the pterygoid is overlapped by the epipterygoid, which has a long articulation with the basisphenoid. Posteriorly the epipterygoid is considerably shortened. It has the same relations with the openings in the brain-case as in other Cynodonts, but it does not extend outwards to articulate with the quadrate, being separated from that bone by a considerable gap and lying as a thin lamina on the mass of the pro-otic. Watson describes a somewhat similar condition in *Protacmon brachyrhinus*, but there the epipterygoid terminates posteriorly in a thickened margin. Anteriorly in our form there is a foramen between the pterygoid and epipterygoid, which continues forward as a groove along the dorsal surface of the pterygoid. This is the opening seen by Broom in *Gomphognathus*, and considered by him to be the internal carotid foramen.

The basioccipital forms most of the floor of the brain-case behind the sella turcica, extending from the condyles to the dorsum sellæ, where a fracture shows it lying on the pro-otics as a thin plate of bone with triangular section. It forms the inner boundary of the internal auditory opening and is perforated on each side by two foramina for the exit of the branches of the XIIth nerve.

Seen in dorsal view the basisphenoid forms the floor of the sella turcica into which the carotid foramina enter. The carotid arteries enter the ventral surface of the basisphenoid far back, and thus pass nearly horizontally forwards through the bone. The side walls of the sella turcica are formed by the anterior superior processes of the pro-otics, which bones lie here between the basisphenoid and basioccipital. Anteriorly to the sella

turcica the basisphenoid is continued forwards as a median bar overlapped laterally by the epipterygoids and then by the pterygoids. The dorsal ridge of this median bar is formed of a thin, high plate.



Cynidiognathus longiceps—Htn.
Photograph of palatal view of type skull.

As in *Diademodon* the foramen jugulare lies just anterior to the occipital condyle and faces downwards; while the fenestra vestibuli looks forwards and outwards, being separated from the foramen jugulare by a thin vertical plate of the periotic mass. The bone above the fenestra, instead of having a vertical face, as in *Diademodon*, is bent horizontally to form an eave

overhanging the fenestra. This eave is deeply notched on its anterior edge. The inner border of the notch is formed by the posterior end of the epipterygoid, the remainder of the border by the pro-otic. This notch must represent the pterygo-paroccipital foramen of *Diademodon*, the retraction of the epipterygoid from the quadrate giving rise to the open form. The foramen for the exit of the VIIth nerve is larger and nearer the pituitary fossa than in *Diademodon*.

The periotic (pro-otic) forms most of the side wall of the brain-case behind the dorsum sellæ, articulating behind with the fused exoccipital and supraoccipital, the latter forming the posterior wall of the canal for the IXth-XIth nerves.

The paroccipital process is quadrangular in section, and not triangular as in *Diademodon*.

Quadrate.—Another feature of interest lies in the quadrate mass. The quadrate is a plate of bone with a slightly hollowed anterior surface, and lies on the anterior face of the squamosal, being furnished with an outer flange which is clasped by the squamosal. It has no pterygoid wing. The quadrato-jugal is lateral to the quadrate. It is bifid in character, consisting of a larger anterior vertical thin plate and a smaller posterior one which clasp the lower edge of the squamosal between them. There is probably a quadrate foramen between the quadrate and the quadrato-jugal. A somewhat similar quadrate complex exists in *Protacmon*, but there the quadrato-jugal spreads inwards between the quadrate and squamosal.

Discussion of the relationship of this type to other Cynodonts is deferred until a more complete account of the fossils of the Upper Beaufort Beds is prepared. It is sufficient here to point to some of the advanced features which this form possesses—the complete loss of the quadrate ramus of the pterygoid, the gap between the quadrate and the epipterygoid, loss of a pterygoid process separating the palatine and vomer, and extreme flattening of the basicranium—all logical results from the evolutionary tendencies traced in the Theriodontia, as pointed out recently by Watson.

The absence of an internasal process of the premaxilla and the usurpation of the functions of prevomers by palatine processes of the premaxillæ—functioning as supports to Jacobson's cartilage—are interesting features which are distinctly mammalian in character. The former is paralleled in a large skull of *Cynognathus* from Winnaarsbaaken, Albert District, now in the South African Museum, in which the premaxillæ form a pillar in front of the nostrils reaching upwards and backwards to the nasals.

Cynidiognathus (?) *broomi*, n. sp.

1911. Broom, *Cynognathus berryi*, Proc. Zool. Soc., pl. xlvi, figs. 1, 2.

The occiput and outer view of the bones of the brain-case of an incomplete skull in the South African Museum collection (Cat. No. 1056) were figured by Broom as *Cynognathus berryi*. Recent examination of the specimen has shown that it possesses 10 molars, and cannot therefore belong to the genus *Cynognathus*. In view of the general agreement between the two forms, as far as their features can be compared, I have tentatively placed it in the newly-erected genus.

Comparison with Broom's figures shows that the division between the two condyles is not quite strong enough in the drawing he gave. Further, it seems doubtful whether the epipterygoid passed back to meet the quadrate as described by Broom. As actually preserved, the suture between the pro-otic and epipterygoid is rather more vertical below the big foramen than in his figure and the broken lower edge of the plate shows an interdigitation between the two bones. Unfortunately, the lower outer corner of the palate figured by Broom no longer appears on the specimen, so that it is impossible to settle the point definitely.

No suture can be seen between the exoccipital and paroccipital; the features of the region are mainly as in Watson's description of *Diademodon*. The post-temporal fossa is above the level of the foramen magnum. The fenestra ovalis lies lower than in *Diademodon*.

The basisphenoid and basioccipital in ventral view are somewhat hollowed out, not flat, and in the posterior part there is a well-marked, narrow, shallow, median keel flanked by two narrow elongated grooves which pass forward well beyond the level of the tubera basisphenoidalia.

There is a pronounced occipital boss on the upper border of the foramen magnum.

The series of 10 molars occupy a length of 85 mm. The first is immediately behind the canine. In *Cynognathus* and *Lycorchampsia* there is diastema between the canine and the first molar, which is relatively larger in the latter.

The frontal is more lozenge-shaped than in *Cynognathus crateronotus*, reaching to within 4 or 5 mm. of the orbital border.

The probable length of the skull is 260-270 mm.; the interorbital width is 52 mm., and the width at the canines 58 mm.

Ælurosuchus browni, Broom.

1906. Broom, Trans. Phil. Soc. S. Afr., xvi, 4, p. 376, pl. x.

Broom has described all the visible features of the top of the weathered skull and of the postcranial skeleton. Since the type came into the posses-

sion of the South African Museum (Cat. No. 5875) it has been possible to display the general features of the palate and basicranium, and to show that the form must be classed among the Bauriamorpha.

The palatal aspect is similar to that of *Bauria*, except that it is probable that the secondary palate is more fully formed than in that genus. The septum dividing the posterior nares was figured by Broom. There is a large suborbital fossa, bounded posteriorly by the pterygoid and laterally by a bone which expands forwards and is probably the ectopterygoid. The bone substance is very soft and sutures are usually indistinguishable in a sandstone matrix such as this fossil possesses. There is a large cordate interpterygoid vacuity.

The quadrate ramus of the pterygoid meets the quadrate, and between it and the paroccipital there is a very considerable space.

The epipterygoid is a flat bone, fairly narrow in the middle, but expanded at each end, resting on the quadrate ramus of the pterygoid and touching the parietal. It is far more like the epipterygoid of the *Therocephalia* than that of the *Cynodontia*.

The basisphenoid is broad, and apparently extends in the middle line to the back of the interpterygoid vacuity. Near the front it is pierced by a single circular foramen, probably the foramen for the carotids. It forms, as usual, part of the border of the fenestra ovale, which is closed by the stapes. The stapes are dumb-bell shaped bones, the outer end lying between the paroccipital, quadrate, articular, and pterygoid.

The paroccipital is shallow—possibly on account of the post-mortem flattening of the skull—but laterally is broad from back to front; its under surface is provided with a broad, shallow groove. Its inner end forms the border of the large foramen jugulare, whilst medial and slightly posterior to the latter is a smaller opening for the exit of the XIIth nerve.

No other details are visible, but enough is seen to place this form in the Bauriamorpha, to which the ill-defined features of the upper surface of the skull would also assign it.

ADDENDUM.

Since the above description of *Cynidiognathus longiceps* was drawn up, Dr Broom has informed me in a verbal communication that the bone hitherto known as basisphenoid in Therapsids (and so described in this paper) is, in his opinion, the parasphenoid. In an immature *Gorgonopsian* skull from the top of the *Cistecephalus* zone, whose basicranial region he has sectioned, he finds the basisphenoid existing as two small ossifications lying in front of the basioccipital—quite distinct from it and from the bone which sends back a thin plate to underlie the basioccipital and which is anteriorly clasped by the pterygoids, extending forwards above them as a median septum bone

—the parasphenoid or vomer. In later life the basisphenoidal ossifications fuse with the posterior portion of this parasphenoid.

According to this view, only the upper posterior portion of the bone called basisphenoid in such figures as the one published by the writer as a section through the brain-case of *Alopecognathus minor* (Ann. S.A. Mus., xii, p. 211), should be known by that name; the remainder is the true parasphenoid.

EXPLANATION OF PLATE.

Cynidiognathus longiceps, gen. et sp. nov.

Fig.

1. Top view of type skull.
2. Side view of type skull.
3. Ventral view of basicranium.
4. Dorsal view of floor of brain-case.
5. Anterior view of left quadrate mass.
6. Ventral view of same.

Cynidiognathus broomi, sp. nov.

7. Side view of type skull.
8. Top view of type skull.

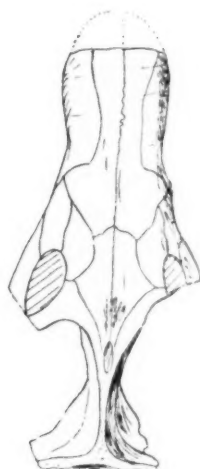
Elurosuchus broeni, Broom.

9. Dorsal view of horizontal section through type skull.

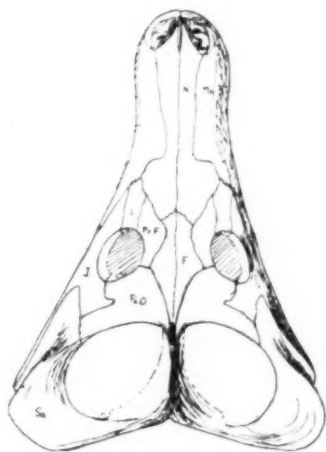
B.O., Basioccipital; B.S., Basisphenoid; d.s., dorsum sellæ; Ep.PT., Epipterygoid; inner vest., inner vestibule of ear; J., Jugal; L., Lachrymal; Mx., Maxilla; N., Nasal; P.Mx., Premaxilla; P.O. (Pro. Ot.), Pro-otic; PAL., Palatine; PAR. OCC., Paroccipital; Po.O., Postorbital; Pr.F., Prefrontal; PT., Pterygoid; Q., Quadrate; Q.J., Quadrato-jugal; SMX., Septomaxilla; SQ., Squamosal; ST., Stapes; TAB., Tabulare; Vo., Vomer.



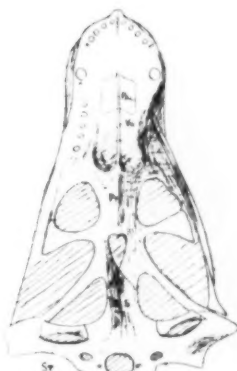
7



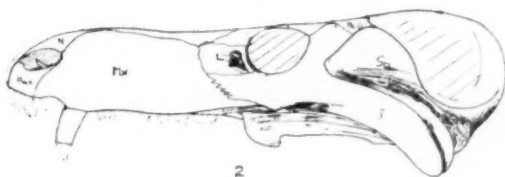
8



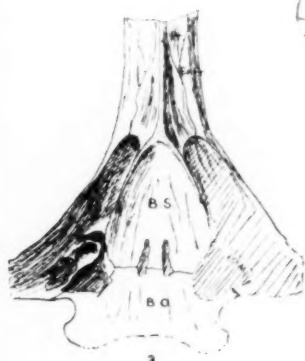
1



4



2



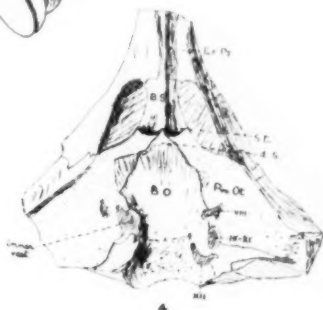
3



5



6



4